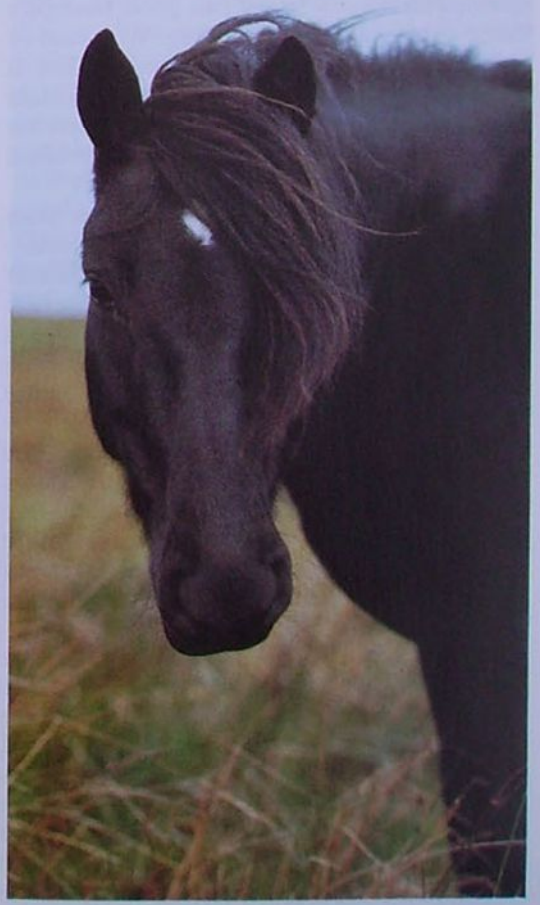
NATIVE PONIES FROM THE DALES

Until 1916 the native ponies bred on the Fells and Dales were virtually identical. Today ponies from both sides of the Pennines can trace their pedigrees to the same ancestors, although they are now two separate breeds. Here we look at the Dales.

The modern Dales pony is one of the largest and heaviest of the native breeds. In general it is a typical Mountain and Moorland pony, known for its qualities of alertness, strength, substance, hardiness and good temperament.

Characteristics The Dales has a pony-type head which is held high and shows good width between the eyes, with well-placed ears and an intelligent, kindly expression. The profile is never dished (slightly concave). A few ponies still show the old-fashioned head which is slightly longer–a legacy, probably, from an infusion of roadster (trotting horse) blood of earlier times. The neck is strong and of good length, with a marked muscular crest which in the stallions is enormous. The shoulders show

Above: Typical Dales country –Upper Nidderdale, Yorkshire. From earliest times the ponies of northern England have been famed for their strength, speed and toughness.



Right: The most common colour is black, and the only possible white markings are a small white star or snip on the head, and on the coronet (top of the hoof) of the hindlegs.

a good slope and are well muscled, with withers that are not too fine, leading into a short, strong back and a body that shows plenty of depth. The quarters and loins are deep and powerful.

As in any working animal, the legs and feet are of great importance. The Dales have excellent limbs, with strong, muscular forearms, and short cannon bones with a circumference of at least 23cm (9in) of quality flat, flinty bone. The cannons may look 'short of bone' (rather narrow) from the front because they are so flat, but when viewed from the side their ample circumference is apparent. The feet are open, round, with a well-developed frog (the elastic horny substance in the middle of the sole of the foot), and are of strong 'blue' horn.

At the walk a Dales pony has a long stride and shows great flexibility of the joints. Traditionally it is expected that this flexibility allows the whole of the sole of the foot to be seen from behind. The trot is a truly spectacular pace, with a distinctive 'all fours' rhythm and energetic high knee and hock action. This is the typical pace of the breed, and the ponies can keep it up for hours on end, averaging a steady 30km (20 miles) per hour.

Dales and Fells To the unitiated (and to most people living in the south of England who see few Dales and Fells), it is not easy to distinguish the breeds. Although the official maximum height of the Dales is slightly taller than that of the Fells, many individuals of both breeds are around 13.2 to 13.3 hands (137cm/54in to 139cm/55in). The ideal way to distinguish them is to see two good examples side by side, preferably moving. With bad or indifferent specimens even breeders find it almost impossible to tell them apart. (Note that an individual member of the Fells breed is known as a Fell, whereas an individual member of the Dales is called a Dales.)

In general, the Dales' head is shorter than the Fell's, and overall the body is shorter-backed, although the Fell is probably shorter from the point of the hip to the root of the tail. Viewed from the front, the Dales appears particularly square because of its wide chest and girth. Fell feet are far neater and smaller than those of the Dales, and the legs may appear from the front to have more bone. The action at the trot, too, is different–the Dales showing a more pronounced knee and hock movement, and consequently a rather more vigorous pace. Because of the great flexibility of the joints, the back remains very level when the pony is moving.

Shared history The early breeds have a common history. Both were developed from the native ponies of the region which, together with the ancestors of the other Mountain and Moorland breeds, reached the British Isles from Europe many centuries ago. They were probably first used as chariot ponies by the ancient Britons, before being recruited by the Romans as pack ponies and in the construction of Hadrian's Wall. There is little doubt that the Romans crossed these northern native ponies with black Friesian horses from Europe to increase the former's size and strength. The Friesian blood is largely responsible for the dark colour of both breeds and, to some extent, for their remarkable ability as trotting animals. The Anglo-Saxons and Normans continued using them for agriculture, especially shepherding, riding, and pulling sledges, a common form of transport before the advent of roads.

In the north during Tudor times a most important influence began to appear. Certainly on the west of the Pennines Scottish Galloway ponies (a breed that itself had been

Above: Many Dales are now being schooled for riding and for inter-breed competitions–and very comfortable, sensible rides they are proving to be. Because of their strength, combined with their relatively small size, they make ideal family ponies, being well up to carrying an adult yet temperamentally suitable for children.

Below: Just a few hill farmers keep their ponies out all year round.

Above: For generations local farmers used Dales ponies on their upland farms. Before the age of mechanisation there were few tasks that they did not tackle successfully, from mowing and ploughing to carting. Even today a few farmers use them for light carting and for row crop work, and a few are used in forestry where their sure-footedness and handiness enable them to go where tractors cannot. Here the ponies are demonstrating shepherding.

outbred to Friesians) were being crossed with the native ponies. Scottish Galloways were exceptional: black in colour, fast and strong. They had a profound influence on other breeds as well, including the Thoroughbred and the Clydesdale. Exactly when they began to influence the ponies on the east of the Pennines is not clear, but there are records of them near the Swaledale lead mines in the mid-18th century, and Dales farmers were known to have turned them out with their breeding herds at that time. It is thought that from the Galloways and their descendants came the excellent feet and legs of the Dales, and their very free, forward-going action.

The Dales were also influenced by Welsh Cob blood, particularly an imported Welsh Cob stallion, probably Comet 931. A strong, heavy animal of some 15 hands (152cm/60in), Comet stayed in Westmorland to found a great line of trotting ponies. One of his most famous descendants was Linnel Lingcropper. He in turn founded the famous Lingcropper line from which many Fells and some Dales of modern times are descended.

Dales today The modern Dales pony has always been a harness animal *par excellence*, and its spectacular trotting action makes it particularly suitable for this type of work–as it has for many generations. So proud are many Dales breeders of their ponies as harness animals that cantering is not a favoured pace with them, because it is considered a bad fault for a harness pony to break into a canter. This reluctance to school the ponies in canter has been to the breed's disadvantage, as in today's horse world an all-round pony is required, with emphasis on riding qualities. However, the breed is moving with the times and many ponies are now being well schooled for riding. They can give a very spirited ride for experienced horsemen–hunting, show jumping, cross country and long-distance riding–and they do, of course, compete with success in all kinds of driving events.

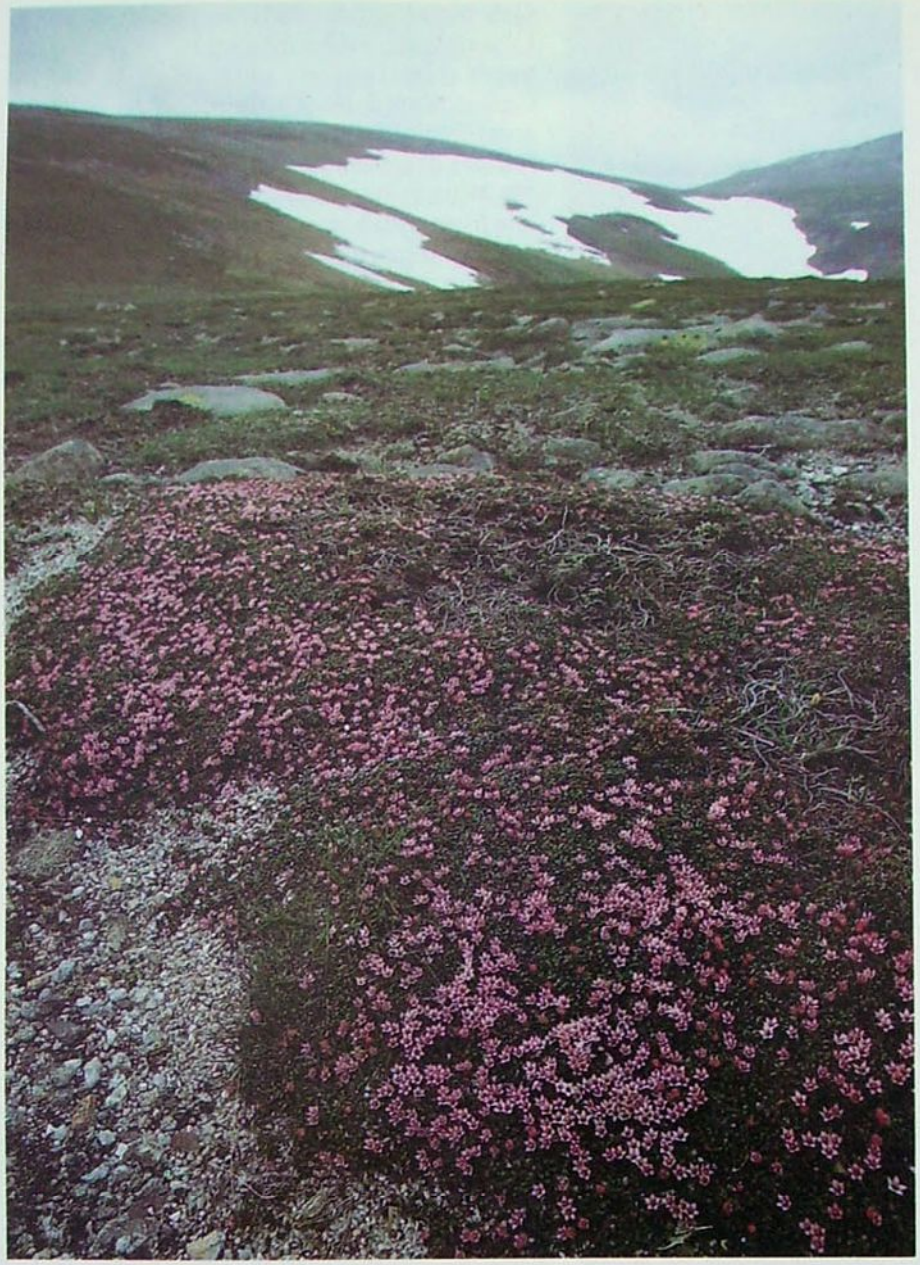
There are virtually no Dales living in a wild or even a semi-wild state today. Those that are kept by hill farmers are not in sufficient numbers to form herds. Nevertheless, as they are typical native ponies and are closely related to the Fells, of which there are still a small number living under semi-wild conditions, there is no reason to suppose that the Dales' behaviour would differ from that of other Mountain and Moorland ponies if they were returned to their native heath. They certainly retain the hardy constitution of the native breeds, and it can be assumed that they would find a living on the rough pasture of the Dales country. Their thick winter coats, the feathering (long tufts of hair) on their legs, and their long tails and manes, are all adaptations for survival in the often bitter conditions of a Dales winter.

Fortunately for the future of the breed, the Dales Pony Society is determined to ensure that, in spite of not having a reserve of ponies living in the wild to which breeders can return for hardy blood, they will do all they can to retain their true native characteristics. With this in view, they are conducting a survey of ponies bred away from their native environment to see if the circumference of the cannon bone is diminishing below the acceptable level–something that is occurring in some other Mountain and Moorland breeds.

How to counteract the loss of hardy, native characteristics is a problem that is exercising the minds of many breeders, and it is encouraging to see a Breed Society that is very much aware of it.

DALES PONY
Size From 13.2 hands (137cm/54in) to 14.2 hands (147cm/58in).
Colour Black, a few browns, bays and greys.
Breeding Similar to the Fell pony.
Distribution To the east of the Pennines in the upper dales of Tyne, Allen, Wear and Tees, and in many moorland areas from the Derbyshire Peaks to the Cheviots as far as the north of Northumberland.

Right: Like all the other Mountain and Moorland breeds, Dales ponies have thick winter coats, long manes and tails, and feathering on the legs which affords protection against harsh conditions.



FRINGE FLORA OF THE BRITISH ISLES

Alpine gentians, Arctic azaleas and saxifrages, even an American orchid–all these are also native in Britain. They are among our rarest species and are known as fringe plants because they are growing at the very limit of their natural ranges here.

Here in the British Isles, lying as we do at the edge of a Continent, a number of our native wild plants are at the limit of their distributions. Many are scarce here but become much more common as you move outside Britain towards the centre of their range. This centre may lie in western Europe or the Mediterranean region; more surprisingly, it may be to the north of us in the Arctic Circle or even to the west in North America.

Cold tolerant northern species The climate is an important factor influencing plant distribution. A large group of plants tolerate the cold, often positively requiring frost and freezing before their seeds can germinate. Many of these plants have their centres of distribution in the Arctic and a few species are at their southern limit in Britain.

One such Arctic plant, *Diapensia lapponica*, is of particular interest for it was only discovered in Britain in 1951, growing as a small colony on a mountain top in western Scotland. This small, low-growing cushion plant with white flowers sometimes grows in such abundance in the Arctic Circle that it may cover the ground as a'diapensia carpet'. Another Arctic species that is rare in Britain, growing only on a few mountains in Scotland and Wales, is tufted saxifrage. A small compact plant with tiny whitish flowers, it grows in tight cushions on rocky mountain ledges above 600m (2000ft).

Arctic-Alpine plants Other cold-tolerant plants have a wider distribution, growing as high Alpine or mountain plants as well as in the Arctic. These species spread south from the Arctic during the last Ice Age; when the ice retreated and conditions became warmer the plants were left stranded as isolated populations in the only places where they could survive–high mountains such as those in the Alps, the Rockies, northern Asia, and also on a few British mountains. These plants are known as Arctic-Alpines.

Snow gentian with its small bright sapphire blue flowers is one such Arctic-Alpine plant. In the British Isles it grows only in Scotland, but abroad it occurs in the Pyrenees, the Alps, the Caucasus, Scandinavia, Greenland and Arctic Canada. Mountain avens is also Arctic-Alpine in its distribution. This low growing evergreen woody shrub, familiar as a rock garden shrub, grows on limestone rocks and meadows. It can be found in the north of England, Scotland and Ireland; elsewhere it grows in Arctic and Sub-Arctic Europe and Asia, in the high mountains of Europe, and in America from the Arctic through the Rocky

Above: Trailing azalea is an Arctic-Alpine species found only on moorland on Orkney and a few mountains on mainland Scotland.

Right: *Diapensia lapponica* grows in a small colony on a mountain in west Scotland.

Mountains south to Colorado.

Alpine species In Britain we have a few Alpine plants that do not grow in the Arctic. One is mossy cyphel which occurs in Scotland and the Inner Hebrides–it is also found in the Pyrenees, the Alps and the Carpathians. A close-growing cushion plant, it is often conspicuous from its overall yellow-green colour rather than from its flowers which are tiny, greenish and without true petals. Spring gentian is also an Alpine plant and is spread throughout the mountainous regions of Europe. In the British Isles its bright blue flowers are one of the features of the Burren in Ireland; they also grow in Teesdale, in the north of England.

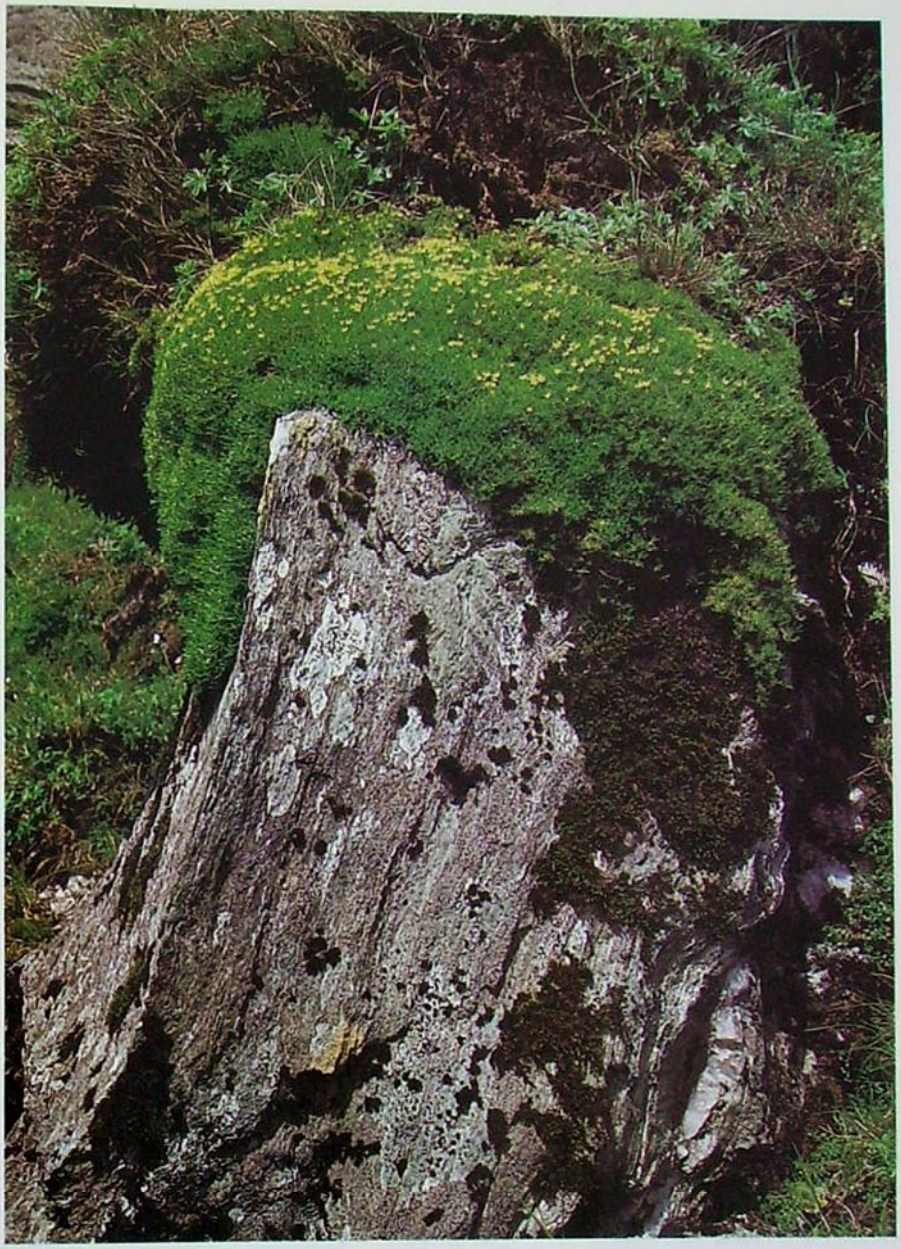
North American species Some North American plants found in Britain are Arctic-Alpines, and as such it is not surprising to find them here because, after being brought south by the Ice Age, they were equally likely to be stranded in the Alps, Britain or North America. But there is one North American species in Britain whose occurrence here cannot be explained so easily. Irish lady's tresses grows only in the far west of the British Isles–in Ireland, Scotland and the Western Isles. It is found nowhere else in Europe, yet it is a common orchid in North America and Kamchatka in the far east of the Soviet Union. The distribution of this orchid, common across the North American continent and with sites in the west of the British Isles, prompts speculation on the British plants being relict from a time when Britain and North America were connected by a land bridge before being separated by continental drift.

Mediterranean and southern In contrast to all those plants that are cold-tolerant and at their southern limit in Britain, there is another group of plants that are intolerant of frost. These are mostly natives of the Mediterranean and the south of Britain is their northern limit. Sea heath grows along parts of the south and east coasts of England and is also found around the Mediterranean, in Madeira and from west Europe to west Asia. Often growing on sand, this tiny prostrate wiry plant has pale rose-pink flowers.

Sea holly has a similar but more northern distribution. It is a coastal plant of southern England, Ireland and the Shetlands, and also occurs in northern Europe and southern Scandinavia. In the Netherlands this plant is of special importance as a dune stabiliser.

Many plants from the Mediterranean occur as casuals in Britain, often persisting through several mild winters until a winter of hard frosts kills them off. Starry clover is one such example.

Lusitanian and western A group of plants that cannot tolerate frost but do not require such high temperatures in summer as the Mediterranean group have centres of distribution in Portugal, Spain and south-west France. These are known as Lusitanian



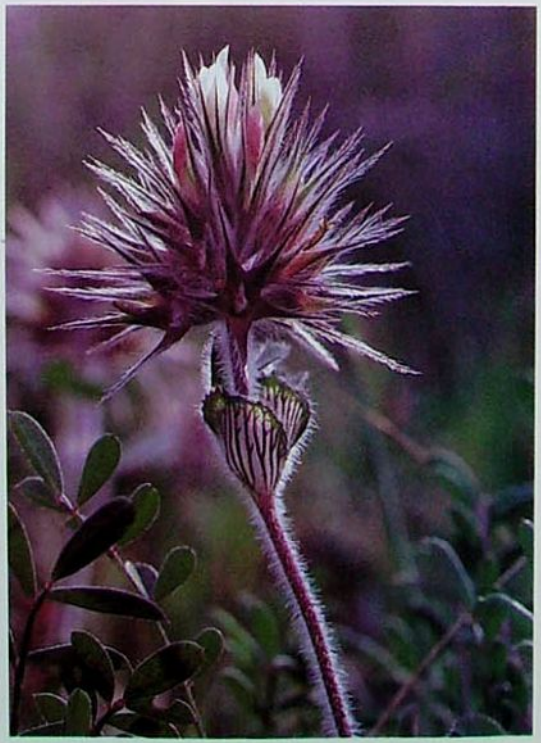
Above: Mossy cyphel is one of our few Alpine species not found in the Arctic. In Britain it occurs in Scotland and the Inner Hebrides, favouring barren rocky slopes and stony terrain where it grows close to the ground forming greenish-yellow cushions. Elsewhere this species occurs in the Pyrenees, the Alps and the Carpathians in Bulgaria and Rumania.

Right: Military orchid is especially rare in Britain, growing only in a few places in south-east England. Its dwindling distribution may be partly attributed to the disappearance of its insect pollinator, or possibly the decline of its soil fungus–no orchid can grow without the presence of a particular fungus in the soil.

Above: The sight of a wood full of bluebells in late spring is familiar enough to us–sometimes we even take it for granted–yet it draws comments of incredulous amazement from foreign visitors, for it is a spectacle unique to Britain. Bluebells are one of the few plants to have their centre of distribution in this country; they also occur in north, west and central France, Belgium and the Netherlands, but there they grow mainly on the coast.

plants, and in the British Isles they occur mainly in Ireland, with occasional records from Cornwall. The strawberry tree grows in rock crevices and on stony ground in oak-wood scrub in Ireland. This tree has reddish-brown bark, dark green leaves and small hanging sprays of creamy-white flowers.

Dense-flowered orchid is another example of a Lusitanian plant (though it also occurs around the Mediterranean).



Right: Starry clover, a plant of the Mediterranean, was recorded as naturalised at Shoreham, Sussex, in 1804, where it has persisted ever since. It was assumed to have been accidentally introduced with some Greek cargo landed in the harbour in the early 19th century. Further north than Sussex this species has had only occasional casual records.

Atlantic and south-western The Atlantic plants are also tolerant of frost but they can survive cooler, wetter summers than the Mediterranean and Lusitanian groups. Included in this group are bell heather and cross-leaved heath. Western gorse, too, is an Atlantic species restricted to Portugal, west Spain, north-west France, south-west Ireland and mainly the west of Britain. Bluebells, which are Atlantic species, are unusual in having their centre of distribution in Britain; they grow at the edge of their range in north, west and central France, Belgium and the Netherlands. Nowhere do they produce such an impressive sight as in this country, though.

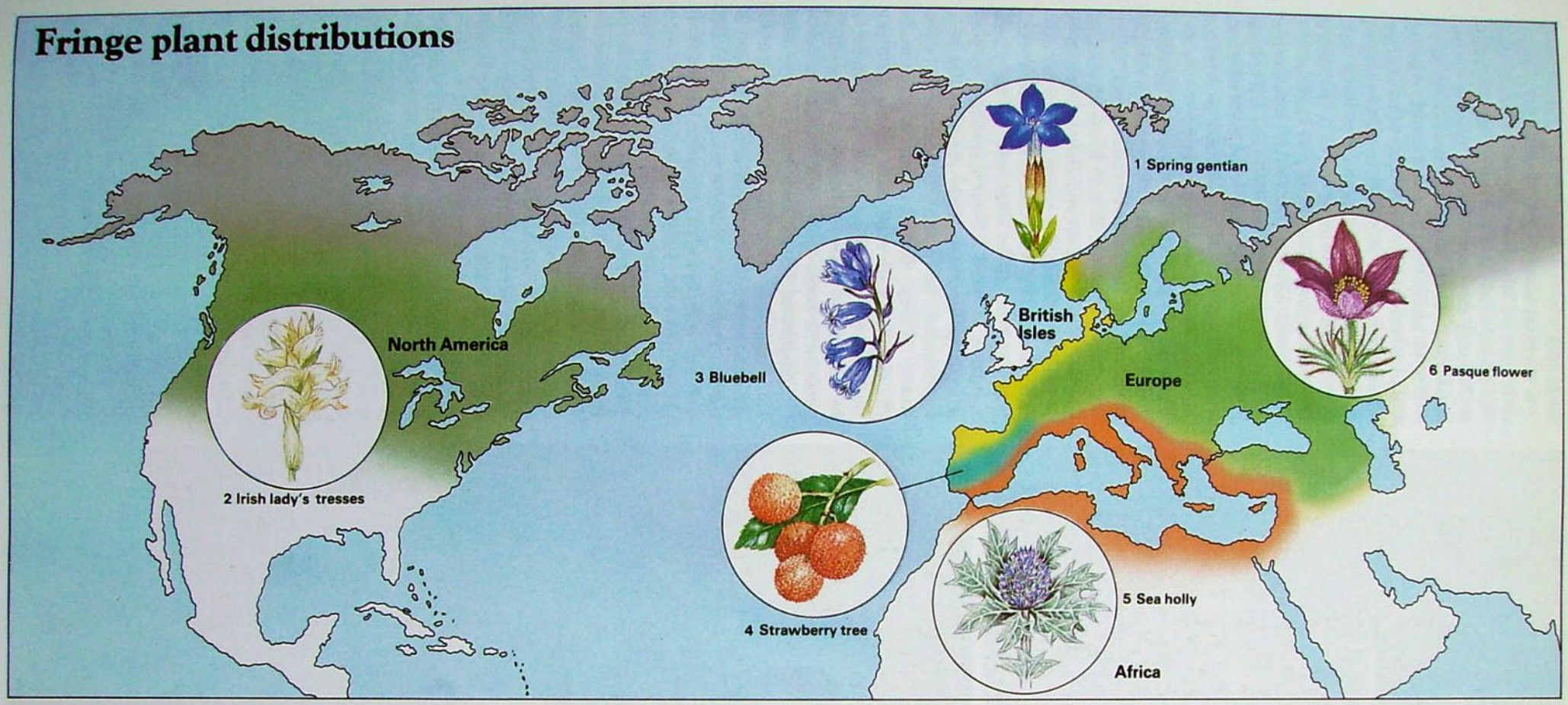
Continental and eastern Plants that have their main centre of distribution in central and south-eastern Europe are known as Continental species. These are frost-tolerant but require hot dry summers, both conditions being typical of the climate in that region. Most of Britain is too damp and cold for such plants, but one region with low rainfall, East Anglia, supports Continental plants such as spring speedwell and pasque flower. Another example of a Continental species is the military orchid, now very local and rare in south-east England but far more widespread on the Continent–from Gotland in Sweden, to Spain and Portugal, Italy, the northern Balkans, Siberia, Caucasus, Asia Minor and southern Russia.

Still more extreme is our rarest orchid, lady's slipper. This plant still grows in abundance in parts of Europe, Scandinavia and northern Asia, but in Britain it now survives on just one site, even though it once occurred in some numbers in northern England. Lady's slipper has always been near the limit of its geographical range in Britain, and such plants are less able to withstand any adverse conditions that may arise.

Cross channel relicts A few species that occur only rarely in southern England are found in abundance across the Channel. The reasons for this disjunct distribution are uncertain. One example is spiked rampion, long present in a number of East Sussex localities but found nowhere else in Britain; it grows in profusion in parts of central Europe where its heart-shaped leaves and greenish-cream flower heads are commonly seen in waysides and meadows in the Alps. Another is moon carrot, again a rare plant in southern and eastern England but common across the Channel. Its cliff edge location supports the speculation that both species might possibly be relict survivors from before the cutting of the Channel around 5500BC.

The geographical distribution of plants is a complex issue, affected by such factors as climate and the biological and historical adaptations of individual species. Much still remains to be discovered about this immense subject.

Fringe plant distributions



1 Arctic, Alpine plants

Plants that are cold tolerant often require frost and freezing for germination.
Diapensia lapponica.
Tufted saxifrage (*Saxifraga caespitosa*).
Snow gentian (*Gentiana nivalis*).
Mountain avens (*Dryas octopetala*).
Mossy cyphel (*Minuartia sedoides*).
Spring gentian (*Gentiana verna*).
Trailing azalea (*Loiseleuria procumbens*).

2 North American plants

One British plant has its distribution centre in North America. The reason for its presence in these islands is unknown: it may be a relict from when the British Isles and North America were connected by a land bridge. It occurs in many parts of North America but over here is found only on the west coast of Ireland.
Irish lady's tresses (*Spiranthes romanzoffiana*).

3 Atlantic plants

The Atlantic or south-western plants are intolerant of frost but can survive even cooler, wetter summers than the Lusitanian species. Consequently they occur on the Atlantic seaboard.
Bell heather (*Erica cinerea*).
Cross-leaved heath (*Erica tetralix*).
Western gorse (*Ulex gallii*).
Bluebell (*Hyacinthoides non-scripta*).

4 Lusitanian plants

These species are also very intolerant of frost but they can survive slightly cooler summers. They have their centre of distribution in Spain, Portugal and south-west France. In the British Isles they occur mainly in western Ireland, although there are some records from Cornwall.
Strawberry tree (*Arbutus unedo*).
Dense-flowered orchid (*Neotinea intacta*).

5 Mediterranean plants

This group of plants cannot tolerate frost and requires hot dry summers. The species are mainly natives of the Mediterranean region; southern Britain is consequently their northern limit. Coastal areas are their preferred habitat here.
Sea heath (*Frankenia laevis*).
Sea holly (*Eryngium maritimum*).
Starry clover (*Trifolium stellatum*).

6 Continental plants

Mainly from central and south-eastern Europe, the Continentals can survive frosty conditions but they do need hot dry summers. A few grow at the edge of their range in southern and eastern England.
Spring speedwell (*Veronica verna*).
Pasque flower (*Pulsatilla vulgaris*).
Military orchid (*Orchis militaris*).
Lady's slipper (*Cypripedium calceolus*).

SNAILS OF DUNES AND DOWNLAND

Certain snails are restricted to dunes, downs and other dry, exposed places, where it is surprising to find such moist-skinned animals thriving. One strategy enabling them to survive is aestivation–the summer equivalent of hibernation.

Below: The heath snail (*Helicella itala*) is found only in exposed habitats, never occurring, for example, in woodland or marshes. These three were photographed on Pewsey Down National Nature Reserve in Wiltshire.

One might expect snails to be confined to damp habitats, yet they can be found in great abundance in what appear to be most unsuitable places–although they become active only when conditions are sufficiently humid. Snails can be found attached to grass stalks on sand dunes, on chalk downland and even on the face of rocks or walls fully exposed to the sun.

A dormant state Not all snails can exploit such exposed situations, however, and those that do are often able to because of a capacity to become dormant in dry, usually warm conditions. Their survival depends on their ability to aestivate, the summertime equivalent of hibernation, when bodily functions are reduced to a low level. At the onset of dry conditions they secrete mucus across the shell opening which dries as a protective film called an epiphragm. In some snails, such as the Roman snail (*Helix pomatia*), this mucus dries to leave a chalky plate with just a pin-sized hole. The mucus is often used to cement the shell aperture to a surface where it will remain attached throughout a dry period.

A capacity to aestivate reaches extremes in desert snails, as an interesting example illustrates. In 1846 two Egyptian desert snails were brought to the British Museum and, as was customary at the time, they were glued to a small wooden tablet and placed in the shell collection. Four years later a museum worker happened to notice that one of the shells appeared to have a fresh epiphragm formed across its aperture and, surprised at this appearance, he placed the shells in tepid water. Within minutes one of the snails emerged from its shell, and by the next day was feeding on cabbage leaf. It lived for a further two years before being given a permanent home glued to a wooden tablet.

Conspicuous family Members of the family Helicidae are often the most conspicuous snails to be found in exposed situations, and in certain conditions this even applies to that well-known species, the common garden snail (*Helix aspersa*). Like the Roman snail, the garden snail is distributed throughout the Mediterranean region, and the absence in Britain of fossils of the species from before the time of the Romans has fostered the suggestion that it may have been introduced here by the Romans as food. *Helix aspersa* can often be seen clustered together on stone walls, especially in coastal areas of south-west England.

Another Mediterranean snail is the sandhill snail (*Theba pisana*), which has a restricted distribution in Britain, with a vulnerable colony in Cornwall and a few others in South Wales and near Dublin. Although it is a popular item of food in many parts of Europe, its presence in Britain and Ireland has not been attributed to the Romans. *Theba pisana* can be seen clustered on the stems of grass tufts, and even in the hottest weather makes little attempt to seek shelter in the surrounding sand. It can probably survive a higher level of desiccation than other British snails.

As well as the sandhill snail, several of our more common helicid snails climb grass stalks and survive well in the hot, dry habitat of sand dunes. The banded snail (*Cernuella virgata*) and the wrinkled snail (*Candidula intersecta*) are the most notable of these, occurring

frequently on sand dunes. By ascending grass stalks, they are in fact avoiding the hottest layer of air that blankets sun-baked sand. These two species are also typical inhabitants of the short grassland of chalk downs, together with the heath snail (*Helicella itala*) and the eccentric snail (*Candidula gigaxii*), so named not because of its behaviour but because of the slightly lop-sided shape of its shell. A helicid with a restricted range, for it reaches the northern limit of its distribution in south-east England, is the Carthusian snail (*Monacha cartusiana*), which shares the habitats of these other downland snails.

Rock snail Another snail that lives in exposed conditions is the tiny rock snail (*Pyramidula rupestris*). It is not a member of the family Helicidae but belongs to the family Pyramidulidae, which contains several species that live in dry, rocky areas extending across Europe and Asia. *Pyramidula rupestris* is widespread in Britain, and dense colonies of the almost black shells of the species are often attached to rocks fully exposed to the sun. This sometimes causes the shells of some older individuals to be bleached white.

Hiding places Apart from these snails, others manage to survive in exposed habitats by seeking out the sparse shelter that is available. Most are tiny, such as the whorl snails, *Truncatellina callicratis* and *T. cylindrica*, and the moss snail (*Pupilla muscorum*), but the larger snail *Ponentina subvirescens*, hides in the roots of plants and under stones close to the sea in south-west England.

One other snail that deserves mention here is the blind snail, *Cecilioides acicula*. Although it spends its life deep in the soil and is rarely seen alive, its shell can often be found on open chalk downland, ants having dug it up after the snail's death and deposited it on the tops of their nests. This strange snail is very small and has a narrow shell, but is related to the giant snails of Africa.

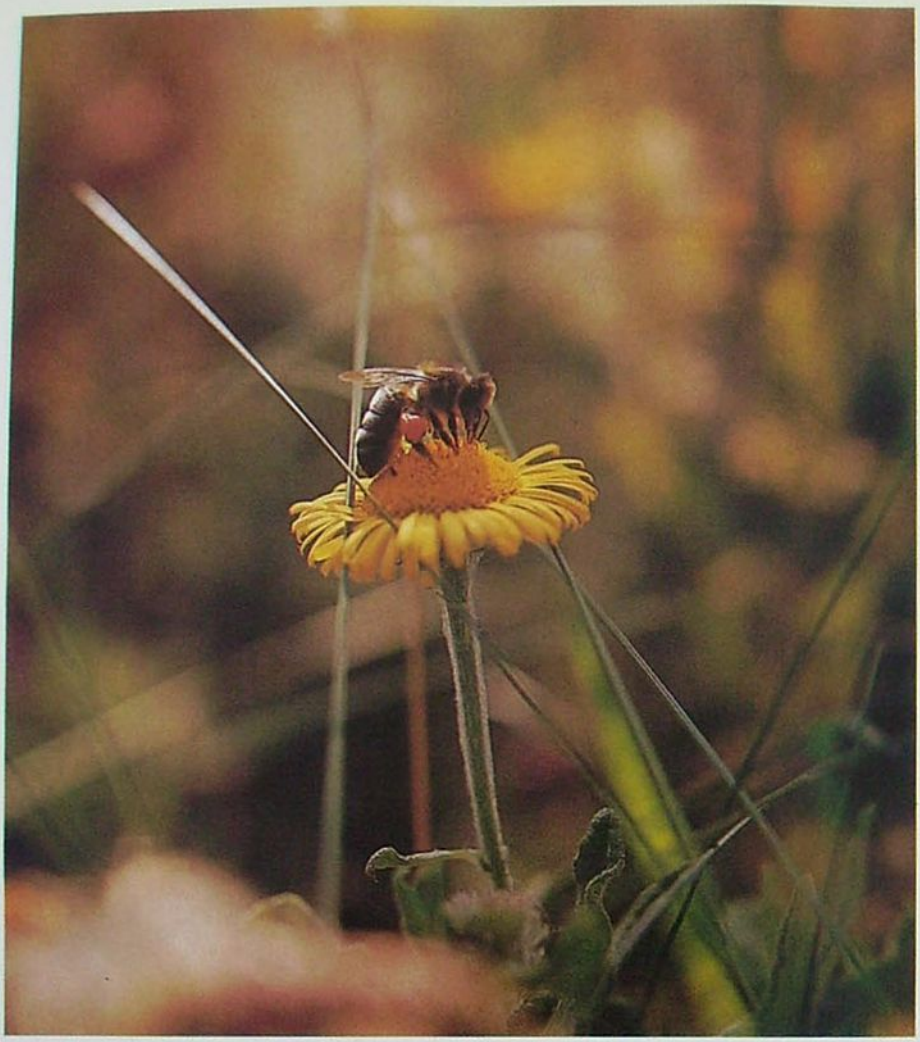
Destruction of habitats The way the land has been farmed in the past probably affects the distribution of our grassland and downland snails. Some species may take a long time to recolonize disturbed land, or they might be affected by grazing sheep or subtle changes in conditions brought about by modern farming practices. When walking across chalk downland the species one encounters in different fields can vary considerably, and although a scanty fence might be all that indicates a boundary, one species may be abundant on one side and completely absent from the other.

A notable victim of agricultural change is the eccentric snail, which favours the longer grass that traditionally borders fields, in strips known as headlands. Today headlands are disappearing from many arable areas because hedgerows (also a useful habitat for the snails) are being removed, and the cultivated field now extends up to a barbed wire fence. There is little chance of this process being reversed, or of the snail recovering its numbers.

Above: Two heath snails on a butterfly orchid. Neither the snail nor the orchid is rare, but each is certainly a good find. These snails have climbed up on to the plant in order to escape the hottest layers of air on the ground surface.

Below right: The pointed snail (*Cochlicella acuta*) occurs in open habitats round our southern and western coasts. A similar cone-shaped snail that lives in even more exposed sites is *Cochlicella barbara*. It, however, is confined to a single colony in Britain, near Falmouth.

Below: The banded snail (*Cernuella virgata*) is one of our most common helicid snails of sand dunes and chalk downland.



THE VARIED LIVES OF BEES

Not all bees resemble the familiar honey or bumble bee. Some are masons, others miners, and a few have adopted the life-style of the cuckoo.

Above: Social bees such as this honey bee collect pollen using a special area of their hindlegs surrounded by curved hairs and called a pollen basket. In this picture the basket can be seen laden with pollen.

Below: Solitary bees also carry pollen on their hindlegs, but on special areas of dense hairs called scopae instead of in a pollen basket. Shown here is a species of mining bee, *Halictus rubicundus*.

In the British Isles we have 250 species of bee, ranging from the unspecialised solitary species to the highly specialised social ones–the bumble bees and honey bees which are among the most advanced of all insects with a well-organised social structure inside their nests.

Clues to the degree of development of bees are found in the length of their tongue, for they and flowers have evolved together: the bees using flowers as sources of food, the flowers using the bees as vehicles for pollination. Consequently there are many examples of close adaptation between the two groups. For example, the nectar of some plants lies so deep within the flower that only the long tongues of bees can reach it. The length of bees' tongues are clues to the type of flowers visited and also their degree of evolutionary specialisation.

Short tongues The least specialised bees, with short, broad tongues, belong to two genera, *Hylaeus* and *Colletes*. The former are quite small (6-10mm/$\frac{1}{4}$-$\frac{1}{2}$in), black and slightly hairy. They drink nectar from shallow flowers and manage to carry some pollen on their front legs, which have a few longish hairs for this purpose.

Bees belonging to the genus *Colletes* are larger than *Hylaeus* bees and have a special patch, called a scopa, of dense hair on each hindleg. This helps the *Colletes* bees to carry pollen from the flowers they visit. These bees make their nests in soil, lining them with a salivary secretion and provisioning them with semi-liquid honey.

Long tongues All other bees have long pointed tongues and can forage in deeper flowers. The group with least well-developed long tongues are the mining bees which include those in the genera *Andrena*, *Halictus* and *Dasypoda*. As their name suggests, mining bees dig their nests in the ground. Each shaft made by *Andrena* bees has several cells containing stores in the form of a 'loaf' of pollen moistened with honey. Some species of *Andrena* have a single generation each year, others have two. *Halictus* bees and their close relatives *Lasioglossum* tend to be small insects with a social life style. Unlike in *Andrena*, where both males and females emerge in spring to mate, in *Halictus* mating takes place in autumn and only mated females survive the winter. Some species are completely social, others less so, leading eventually to a solitary life in some species.

A social life In the fully social species of *Halictus*, the mated female or queen starts a nest in the soil and provisions the cells before laying her eggs in them. The first bees to emerge a few weeks later are all small females, or workers, which enlarge the nest and build small combs of cells using a salivary secretion. The queen lays more eggs in these cells and further worker females are produced. In late summer more eggs are laid. After they hatch the female larvae are kept well fed and grow

Above: Solitary bees are important pollinators of fruit trees. This mining bee, *Andrena pubescens*, is feeding on the nectar of blackthorn, a wild relative of cultivated plums.

Left: Cuckoo bees such as *Nomada* species make no nest of their own, preferring to lay their eggs in the nests of other bees.

Below: This mining bee *Colletes daviesiana* is excavating a nest burrow in loose ground.

large. Eventually they mate with the males, which then die, and the females overwinter to become next year's queens. The difference between this kind of social life and that of the bumble bees is that each cell is normally provisioned before an egg is laid so that there is seldom any contact between larva and adult.

Masons and cutters Leaf-cutter bees (*Megachile*) and mason bees (*Osmia*) usually make their solitary nests in holes in wood or in gaps in walls. Their nests are built either from mud or from specially cut pieces of leaf. These bees have much longer tongues than those of *Andrena* bees and in this respect resemble bumble bees. They differ from other groups in having their pollen gathering scopae underneath their abdomen. Despite having relatively long tongues they tend to choose open flowers and are often seen practically wallowing in bellflowers.

The leaf-cutters (*Megachile*) are fascinating to watch as they cut ovals and circles from rose leaves with their mandibles. The whole process of landing, cutting and flying away with the leaf safely tucked beneath their body only takes a few seconds. The mason bees (*Osmia*) use mud to build their nest cells in the gaps of walls–they have even been known to jam the locks of outhouses with their cells. The mason bees are also renowned for nesting between brickwork where the mortar has fallen away.

Baskets of pollen The most highly evolved bees are the true bumble bees (*Bombus*) and the honey bee (*Apis mellifera*), all of which live a social life, have long tongues and gather pollen in a pollen basket.

The bumble bee year begins when the females, or queens, emerge in spring from their overwintering sites. Most species seek old mouse nests and some, known as carder bees, plait moss to form a nest on the surface of the ground among rough vegetation. The queen forages until she has enough pollen and honey to provision a large cell. The pollen and honey are mixed together and surrounded by a layer of wax, secreted between the plates of her abdomen. She lays a batch of eggs in this cell and when once the larvae have hatched and eaten all the initial store of food, she continues to feed them until they spin silken cocoons and pupate.

The adults which emerge from these pupae after two to three weeks are all non-reproductive females, or workers. These are the bumble bees which we see foraging on flowers for most of the year. Their purpose in life is to extend and provision the nest. By summer, the nest contains several hundred bees which have taken over the task of nest building and provisioning from the queen. She spends her time producing more eggs which in turn grow into yet more workers. In late summer she lays male and female eggs which are tended by the workers in a special way: the female eggs and larvae are given

space and food to grow into large females or new queens. They are destined to mate and overwinter as founders of the next season's bumble bee nests.

Hexagons of honey Honey bees are much more organised than the bumble bees in that their nest is larger, with up to 80,000 bees, and more efficient. The cells, again made of wax, are gathered in precisely ordered combs of hexagonal holes. In nature each comb is hung from the roof of a hollow inside a tree but in captivity they are arranged in special beehives. Each cell holds one egg and if it is a brood cell, it has no food stores, the larvae being fed by the workers. The queen produces special secretions to subdue the queen-rearing urges

of the workers and keep the colony working as a unit. These secretions are passed from queen to worker, and from each worker to others.

The death of the queen means the death of the colony as the workers lose purpose and drive. In normal circumstances the whole colony overwinters, using stores of honey as food during warm weather. Colonies disperse by the production of new queens and males– the old queen flies off with a swarm of workers once such a new queen is installed in the hive. Honey bees probably represent the highest point of evolution in the insect world.

Cuckoo in the nest Some bees have forsaken their own nest building habits and have become parasites in the nests of other, often

Above: The cuckoo bee *Psithyrus vestalis* takes over the nest of the similarly patterned bumble bee, *Bombus terrestris*.

Left: Leaf-cutter bees construct cells from rolled sections of leaf, inside which they place a supply of honey and pollen before depositing a single egg. This female *Megachile* is carrying a section of leaf in her jaws.

Below: A mining bee (*Dasypoda*) with pollen.

closely related, bees. The cuckoo bees have lost their pollen collecting apparatus and evolved thicker armour and stronger stings to subdue any resistance. Mining bees are hosts to wasp-like bees which sneak into the mining bee burrows while the owners are away and lay their own eggs in the cells. Each group has its own parasitic cuckoo bee: *Andrena* is attacked by *Nomada*, *Halictus* by *Sphecodes* and *Megachile* by *Coelioxys*. Probably the best-known cuckoo bees are in the genus *Psithyrus* and parasitise bumble bees. Once the *Psithyrus* female has laid her eggs inside a bumble bee nest she kills the host queen; after the eggs hatch the workers feed the young parasites.

Typical bees

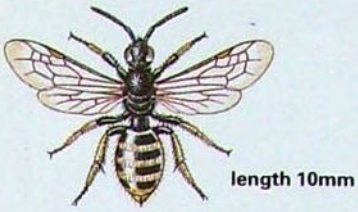
ORDER: HYMENOPTERA

British bee families

Families	species	common name
Colletidae	20	Mining bees
Andrenidae	67	Mining bees
Halictidae	57	Mining bees
Melittidae	6	Mining bees
Megachilidae	34	Leaf cutter and Mason bees
Anthrophoridae	39	Flower bees
Xylocopidae	2	Carpenter bees
Apidae	25	Bumble bees Honey bee

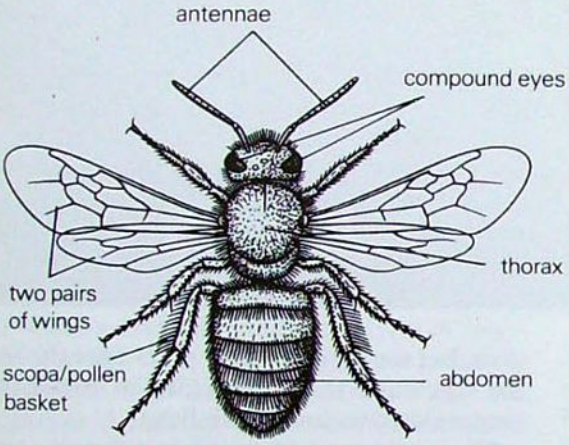
Colletes succinctus

Andrena fulva

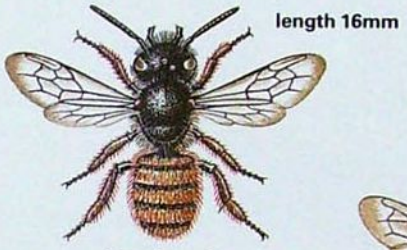


Halictus malachurus

Dasypoda altercator

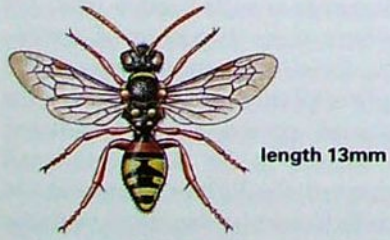


bee characteristics



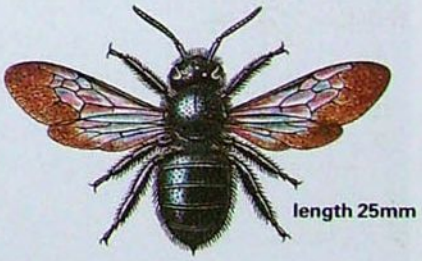
Osmia rufa

Megachile centuncularis

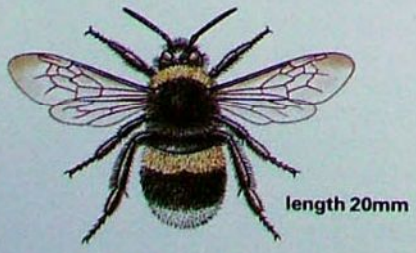


Nomada fulvicornis

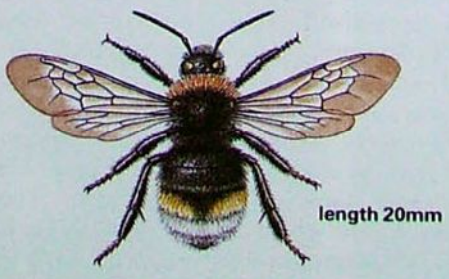
Anthophora plumipes



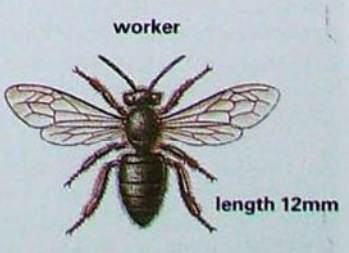
Xylocopa violacea



Bombus lucorum



Psithyrus vestalis



Apis mellifera

IRELAND'S VANISHING PEAT

One seventh of Ireland is covered with peat. For centuries people have been cutting it for fuel, but modern harvesting methods mean that most of Ireland's peat–and with it its bogs and fens–could disappear over the next 30 years.

Above: In areas such as the west of Ireland, where the landscape is predominantly sloping rather than hilly, blanket bog forms in preference to raised bog. This picture, taken in Connemara, shows a typical stretch of blanket bog. In the foreground are the white seeding heads of cotton-grass, a common plant of bogs and acid fens. In the background are the famous Twelve Bens of Connemara, the tallest of which is 730m (2395ft) above sea level.

Peat is composed entirely of the partly decomposed bodies of dead plants. The moist, cool climate of Ireland, poor drainage and gentle slopes have all contributed to the development of peat, and man has also played a part. In well-drained (and therefore drier) habitats the remains of dead plants decompose due to the action of bacteria and fungi. But, where there is too much water that will not drain away, anaerobic conditions develop –no oxygen is available to the decomposing agents, the bacteria and the fungi. They cannot do their work, and so dead plants do not decay but remain more or less intact. Over the years layer upon layer of undecomposed material builds up to form peat. The process is slow, but during the 10,000 years since the last Ice Age more than 10m (33ft) of peat have accumulated in some Irish bogs.

There are two basic types of peat, one formed from fen, the other from raised bog or blanket bog. Since fen and bog support quite different types of vegetation, fen peat and bog peat differ in their compositions.

Fen peat Sometimes called sedge peat, fen peat forms where there is plenty of water–usually in the form of a small lake–and a plentiful supply of plant nutrients. During the early post-glacial period such conditions abounded in Ireland in the numerous small lakes that occupied the hollows between the low rounded hills known as drumlins. Aquatic plants and species typical of lake margins, such as sedges and rushes, grew lushly. When they died, the remains sank to the lake bottoms and accumulated as rotting vegetable matter. Because there was little through-flow of water anaerobic conditions developed and peat began to form on the lake-bed. Slowly the lakes filled with peat, until there was no visible water, just a sodden fen.

Raised and blanket bogs When the lake became completely filled with fen peat the accumulating surface mat of vegetation began to rise above the water table, and conditions changed. The plants on the mat were now unable to take up nutrients in the water of the lake and therefore nutrient-poor, acidic conditions developed–acidic because the

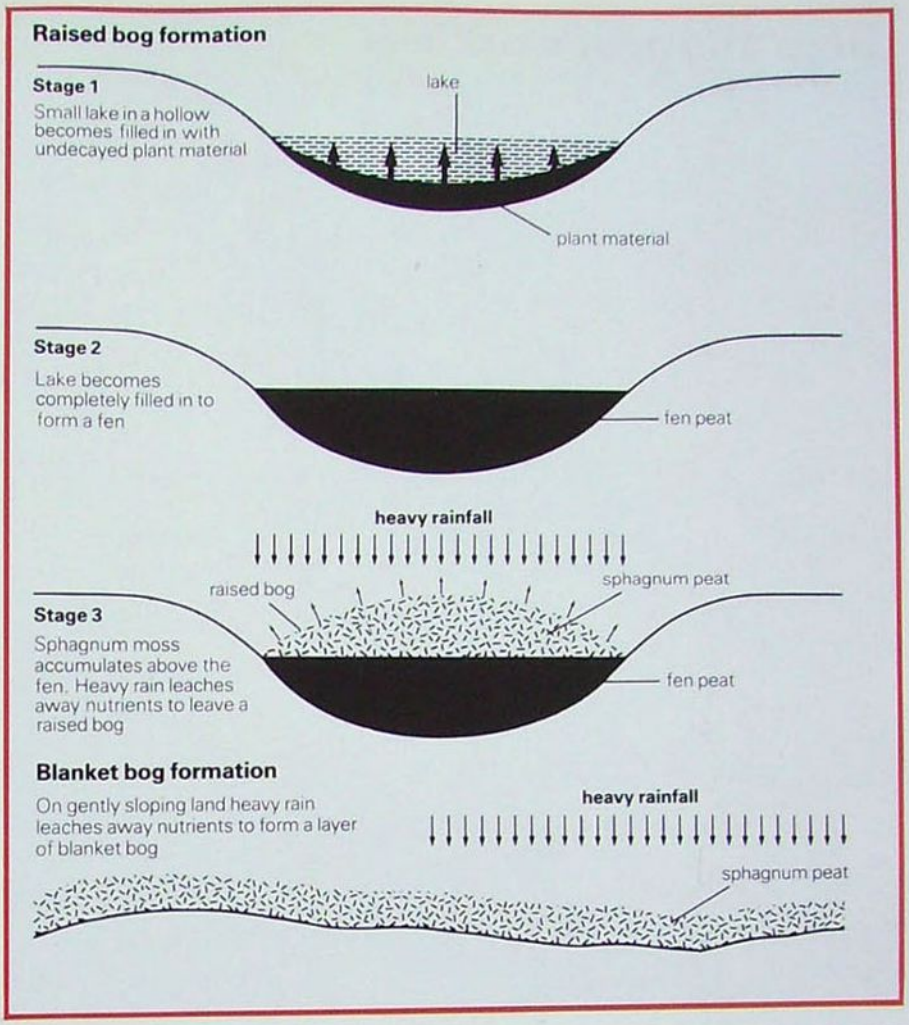
acids released by the partially decayed vegetation were no longer neutralised by the nutrients in the water. The result was that plants requiring richer, less acidic habitats died out. The fen had turned into a bog, and a new plant community developed dominated by various species of *Sphagnum*–mosses typical of bogs.

In this type of bog, known as a raised bog, the only way that nutrients can reach the surface vegetation is in the rain water which, of course, contains almost no dissolved salts. Thus the surface becomes more acidic and only plants capable of tolerating these special conditions survive.

Among the plants found on raised bogs are the insectivorous sundews, which gain their essential minerals and nitrogen from the insects that they trap. In bog pools, bladderwort, another insectivore, is sometimes found. As well as *Sphagnum* moss, the raised bogs are inhabited by cotton-grass (actually a sedge), bog asphodel, bog myrtle and various grasses including purple moor-grass. Many members of the heath family tolerate wet, acid bogs, including cross-leaved heath, bog rosemary and ling. The peat formed from these plants is composed mainly of *Sphagnum* moss with smaller quantities of heathers, grasses and sedges.

Raised bogs develop in hollows, where lakes or fens formed, and occasionally on other flat areas of land. But on the gentle slopes of western Ireland, a different type of bog–blanket bog– has formed. In these areas the rainfall is high and evaporation low. The constant drenching of the land means that plant nutrients are rapidly leached away. The acid from decaying plants is not neutralised by dissolved mineral salts, so that conditions similar to those on raised bogs arise. The remains of plants do not decompose, and a blanket of peat (rarely deeper than 2m/6ft) envelopes the slopes, except the steepest ones. The plants inhabiting blanket bogs are the same as those on raised bogs–heathers, purple moor-grass, sedges, *Sphagnum* moss and others.

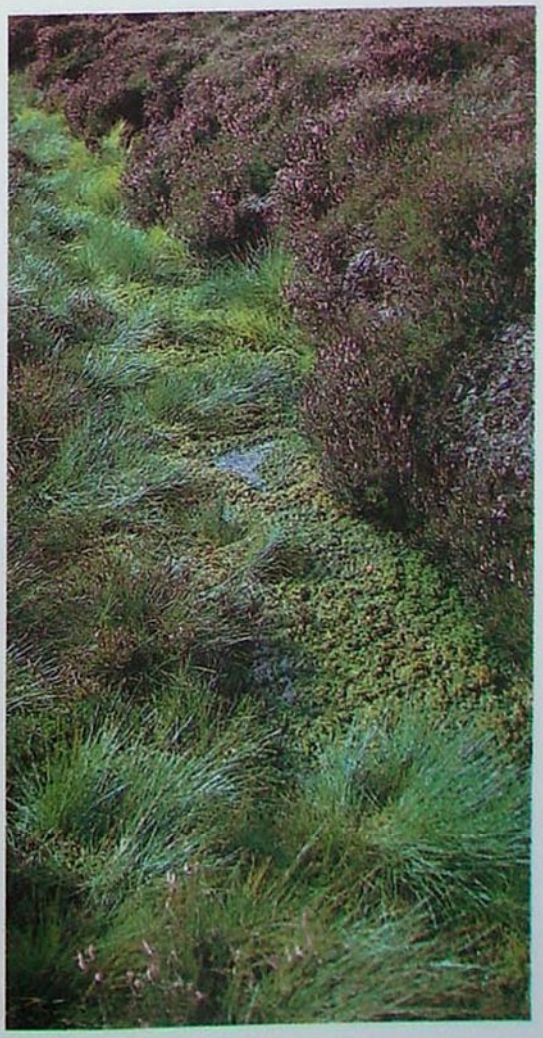
Records of the past Man has assisted the spread of blanket peat in western Ireland. The

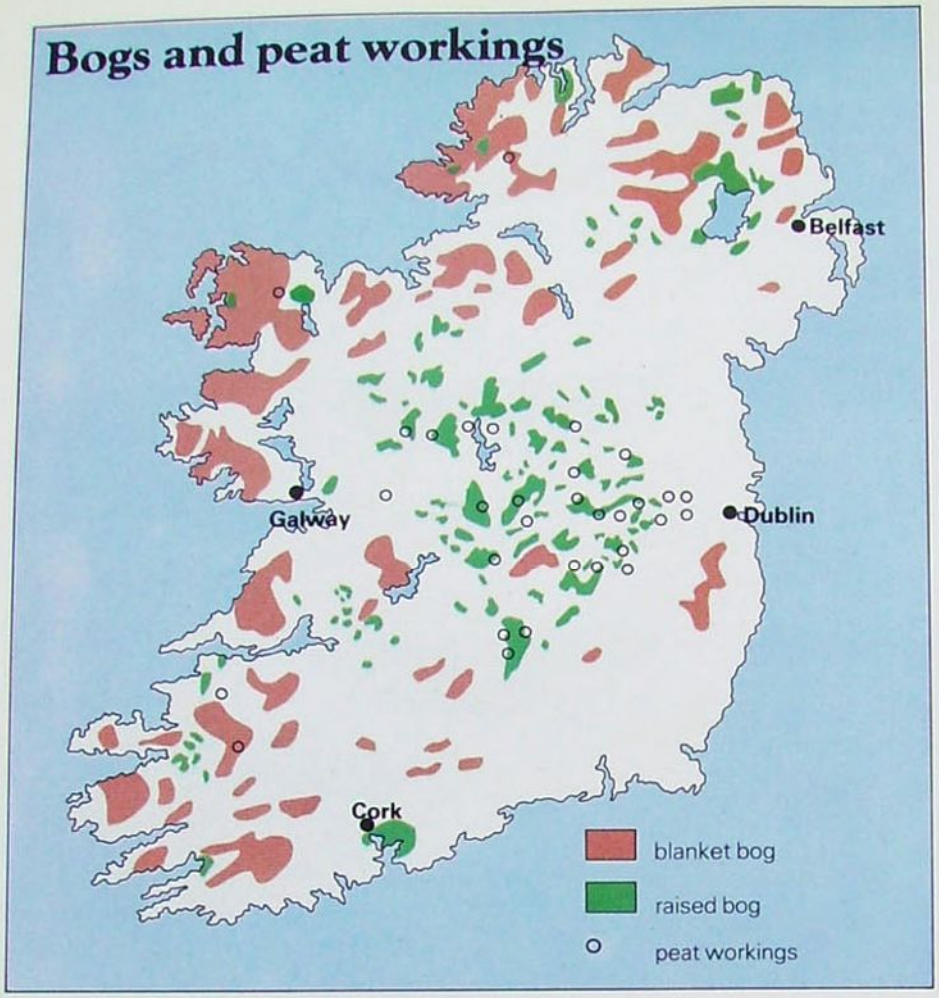


Above: The formation of raised and blanket bogs. Note how fen is a stage towards the creation of a raised bog.

Right: An old abandoned peat face where cutting once took place. Such faces are slowly recolonized by bog plants. Here, heather and various species of lichen have moved in.

Below: Bog rosemary, a plant closely related to heather, can survive in the acid conditions of a bog.





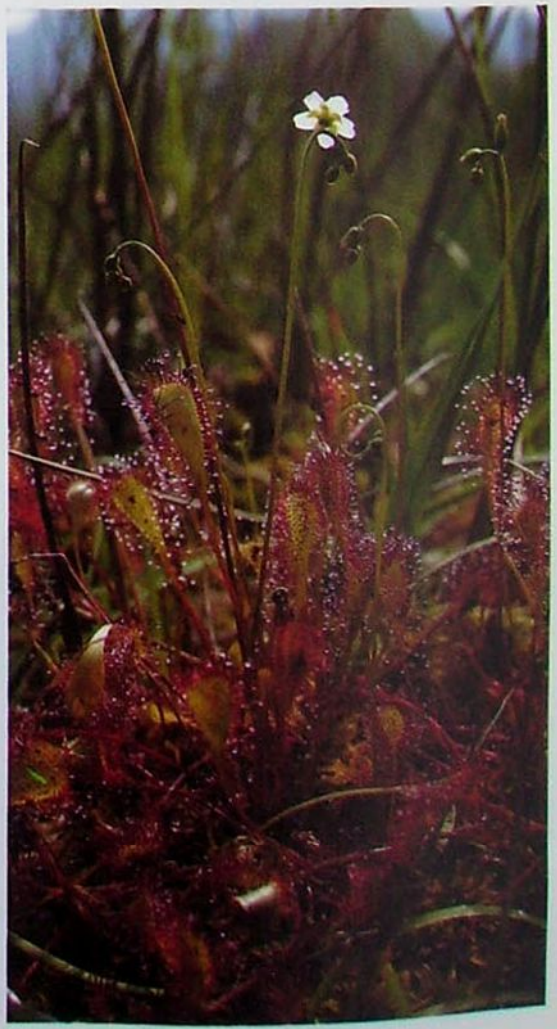
Above: The distribution of blanket bogs and raised bogs in Ireland. The former tend to occur in the west of Ireland, and also the north, while the latter are confined mostly to central Ireland. Also marked are the sites where the peat is being extracted.

Stone Age and Bronze Age people cut down the woodlands that developed after the Ice Age, and in the clearings practised primitive agriculture. After they moved on, or died out, the woodlands did not always regenerate because the soil was too impoverished. The blanket of peat slowly covered the remains of the dwelling houses, tombs and even the ancient fields of these people. It is fortunate for us that the peat has preserved these traces of our ancestors, for archaeologists can learn much from the peat-engulfed remains.

Peat is a marvellous preservative and the bogs of Ireland sometimes yield surprising evidence of past epochs–the preserved bodies of people have been unearthed as well as hoards of butter. The stumps of trees are often revealed when peat is removed. Some of these are the remains of Scots pines which grew in abundance about 7000 years ago. Other stumps are of oak. The wood is well preserved and has been used for a variety of purposes–building, fuel, and carving into ornaments or food vessels.

The peat also serves as a record of the environment throughout the 10,000 years since the last Ice Age. Each layer contains information about the plants growing in the fen or bog, and nearby, at that time. By studying the preserved remains–pollen grains, fruits and seeds, flowers, wood and leaves–botanists can build up a picture of the succession of vegetation.

Left: Bog asphodel is a perennial member of the lily family that spreads through bogs and fens by means of underground runners. It grows to a height of 40cm (16in) and flowers in July and August.



Right: Some plants of bogs supplement their meagre nutrient intake by trapping and digesting insects. Sundews, such as this great sundew, achieve this by having sticky leaves.

Peat as fuel The great peatlands of Ireland are not just a habitat for plants and animals, or a living archive preserving details of past epochs. They provide a valuable resource–peat–in a country which, until recently had no other reserves of fuel.

From the time immemorial, people have been cutting peat by hand for fuel. This was done by digging into the bog to form a vertical face, from which the sods of turf were scooped using an implement like a garden spade. The sods, each about 30cm (1ft) long and 10cm (4in) square, were gathered into small stacks to dry during the summer. Then they were formed into larger stacks and finally carted, usually in baskets on the backs of donkeys, to the farmhouse. Turf fires provided warmth and were used for cooking; they were never allowed to go out.

Modern methods Nowadays, this source of energy is harnessed in specially designed power stations. The Republic of Ireland is the only country, apart from the Soviet Union, in which electricity is generated in peat-fired power stations. The seven major peat stations consumed over 2.5 million tonnes of peat in 1983 and there are several smaller stations supplied with peat by local peat-cutters.

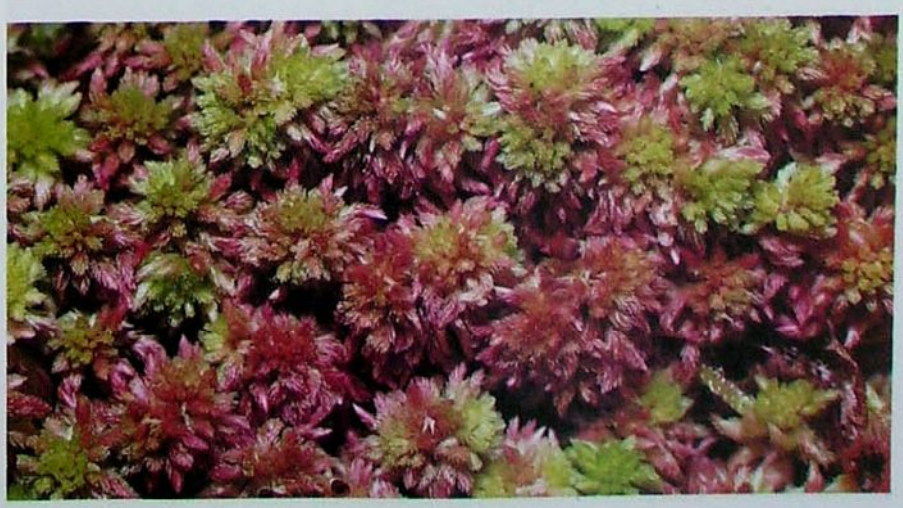
The Peat Development Authority, Bord na Móna, has 80,000ha (200,000 acres) of bog under active use. As well as the peat for the electricity stations, the Bord extracts peat for the production of briquettes–highly compressed peat for use as a domestic fuel instead of coal–and for use in horticulture. Irish moss peat is exported throughout the world for use in nurseries and gardens, and over 1.3 million cubic metres of moss peat was extracted in 1983. Plans are already in hand to open a further 30,000ha (70,000 acres) for peat extractions.

The peat is 'mined' on a vast scale using specially designed machines, like giant combine harvesters. They operate in various ways. Some scoop the top 1cm ($\frac{1}{2}$in) off the bog, and leave a loose layer of powdered peat to dry. This is later gathered by other machines and used in the briquette and moss peat factories, and in power stations as milled peat. Other machines cut the raw peat into sods like those produced by the traditional hand-cutting. Each machine can harvest 5000 tonnes of peat a month.

Concern for the future While this commercial exploitation provides a valuable resource, it causes as much damage to the landscape as open-cast mining. For all practical purposes peat is not a renewable resource, and at the present rate of exploitation there will be no large bogs left in 30 years. There is now a considerable anxiety that these ancient habitats will be eliminated, and there is special concern for the few remaining intact fens and large raised bogs. In Northern Ireland, a number of valuable intact bogs have been acquired as nature reserves, but in the Republic, few attempts have so far been made to conserve bog and peatland habitats.

Above: Traditional peat-cutting in operation in County Kerry. The sods of peat have been stacked into groups and will later be taken away to dry out for the winter.

Given 10,000 years, and no disturbance, the peatlands would regenerate naturally, but that does not mean Ireland should destroy all its bogs. Small-scale cutting by local people does some harm, but it also does good, for the old, abandoned peat-faces provide habitats for interesting plants. But the large-scale 'mining' is different–it is completely destructive. Also destructive is the widescale planting of peatlands with conifer plantations. A balance has to be found between the need for fuels and the need to retain some of these habitats as living bogs, slowly growing as plants live out the cycles of their much shorter lives.



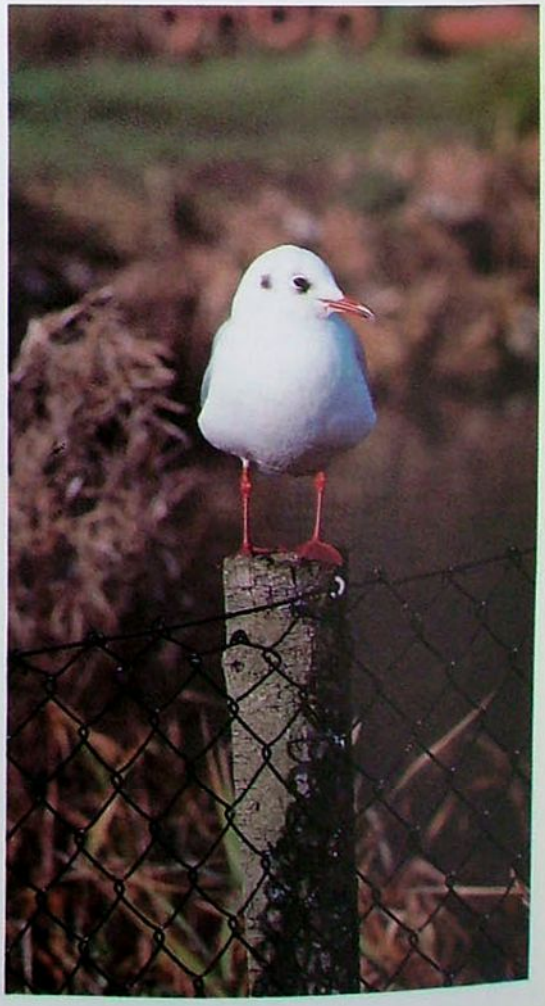
Below: Few plants are capable of surviving in such acidic conditions as those tolerated by *Sphagnum* moss. The species shown here is *S. capillifolium*, one of the more common species of bogs, where it is usually found on the top of hummocks.

BIRDS OF THE ITCHEN VALLEY

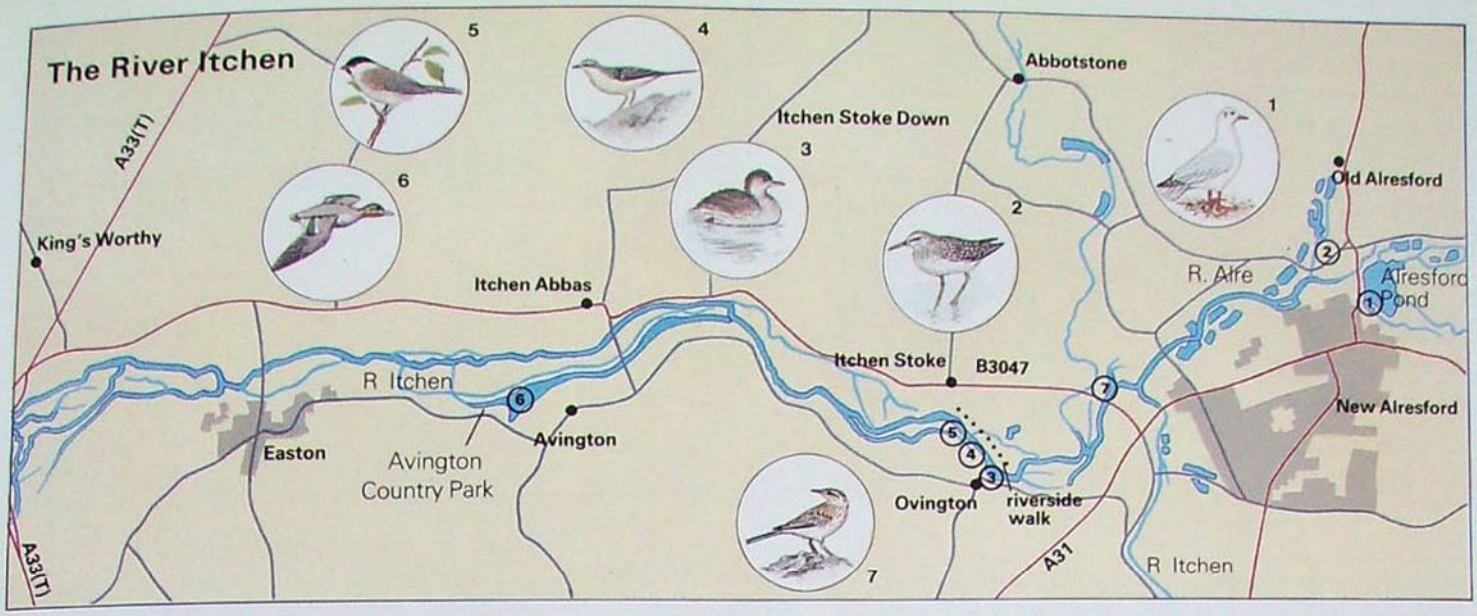
On this field trip along Hampshire's River Itchen, ornithologist Chris Feare demonstrates how to name a gull from its wing markings, count a flock and use a field guide–and how not to worry if an eagerly expected species fails to turn up.

Our field trip was on a mild December day: we travelled by car to five places in the valley of the River Itchen in Hampshire. The first stop was the lake-sized Alresford Pond, where we looked across towards the reed-beds that lined the other side. Scattered about on the water were five different species of duck–teal, shoveler, tufted duck, mallard and pochard–as well as Canada goose, coot and a solitary mute swan. Far more numerous than these waterfowl were the gulls, and our interest centred on these.

Mirrors or leading edges Chris showed me how to distinguish the two gull species on the lake. 'These are Britain's two species of small gulls–black-headed and common,' he



Above: A stretch of the Itchen in the area visited. It is a typical chalk stream–shallow and fast-flowing, often dividing into two or more channels. Its bed is of muddy sand in places and shingle in others. On either side there are pastures, with thickets and groves of small trees such as willow, alder or ash. Such a stretch would be good for little grebes, grey wagtails and moorhens, all of which we saw, as well as several black-headed gulls (right), which are white-headed in winter.



said. 'The majority here are black-headed. They are slightly smaller and slightly paler, and when one opens its wings,' he fetched out a pocket field guide and quickly found the page, 'the wingtip has a black rear edge, while the whole wing has a brilliant white leading edge. On common gulls, the whole wingtip is black, not just the rear edge, but in the black it has two or three white blobs called mirrors.'

We watched the occasional gull take off or fly in from the farmland around, and practised identifying them by their wingtips. As they flew overhead, we could confirm our decision by the leg colour, for black-headed gulls have red legs, while common gulls have greenish legs.

Chris showed me how to count a large flock of birds by 'blocking them off' in groups: for example, the reflection of a line of trees created a dark area on the water, and this enclosed about 20 gulls. Using features like this, the technique is to imagine a geometrical grid of squares on the water, each big enough to contain, say, 20 birds. One then has to count the squares and simply multiply by 20. As a demonstration, we counted the gulls carefully out loud and discussed which was the best way to divide the flock, eventually arriving at a figure of 300 gulls. With experience, the process goes faster.

A solitary sandpiper We left the pond and drove on. Stopping where the road crossed a stream, we got out and surveyed the scene with binoculars. After a few minutes Chris saw something. 'There's a bird there that just might be a common sandpiper, which would be very surprising because it should be wintering in tropical West Africa!'

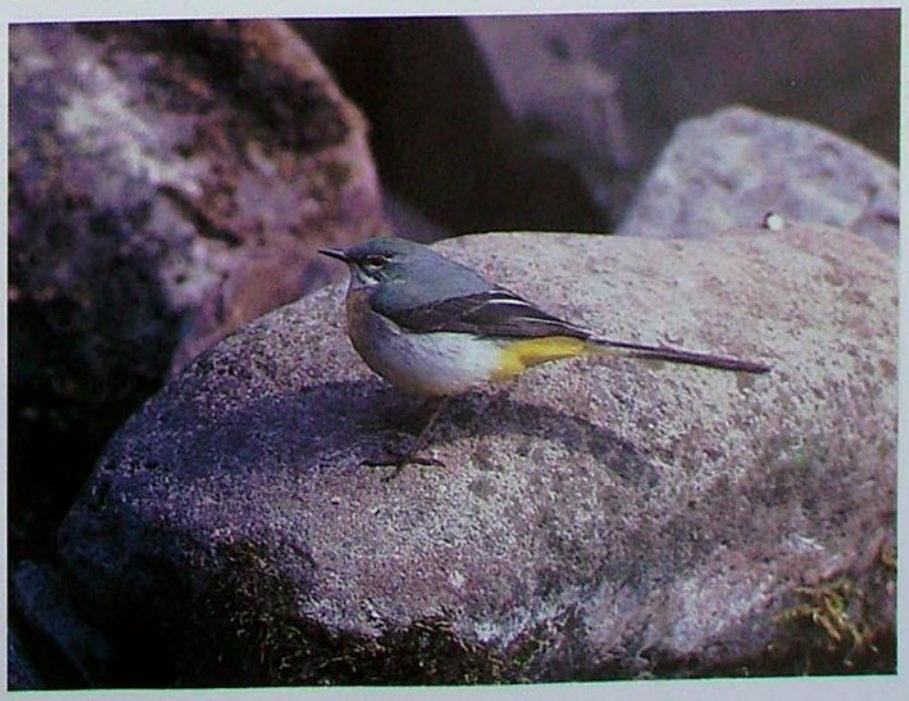
There, about 25m (80ft) away, stood a small wading bird with long legs and beak, mud-grey above with whitish underparts. Chris said it was bobbing its tail up and down, though it took me a minute to become aware of this jerky movement, which is a characteristic feature of the common sandpiper. We put on wellingtons and waded up the stream for a closer look, and soon our first guess was cast in doubt: our bird had green legs, while the common sandpiper's legs are brown. This left the possibility that it was either a green sandpiper or a wood sandpiper.

'As we approach, it'll probably take off,' he said quietly. 'When it does, watch for three things: see if there's a white stripe on the back of the wings; see if the underwing is pale or dark; and see if there is white on the rump. If we're lucky it will call as it flies, and that'll help as well.'

The bird did take off: it lacked a white wing stripe, and had a dark underwing. The rump was clear white. Then it called – a single high note and then two syllables, sounding like 'tit-*loo*-et'. We returned to dry land and opened the field guide: not only the leg colour, but the absence of the white wing stripe, and the presence of the white plumage on the rump, completely refuted the possibility of its being a common sandpiper. The dark underwing identified it as a green sandpiper, but we also used its call to separate it from the wood sandpiper which, as the field guide stated, has

Above: The route, with insets showing some of the birds. Our trip took nearly six hours and covered a distance of about 13km (8 miles). Birds illustrated, in the order seen on the walk, are: **1** black-headed gull; **2** green sandpiper; **3** little grebe; **4** grey wagtail; **5** marsh tit; **6** teal; **7** water pipit.

Below: While walking on the riverside path we frequently saw two grey wagtails. They walked along the water's edge and stopped now and then to catch worms and other food. Quite often one would launch into an elegant, fluttering flight over the river, swooping to catch an insect from the surface.



a 'chiff-iff-if' call.

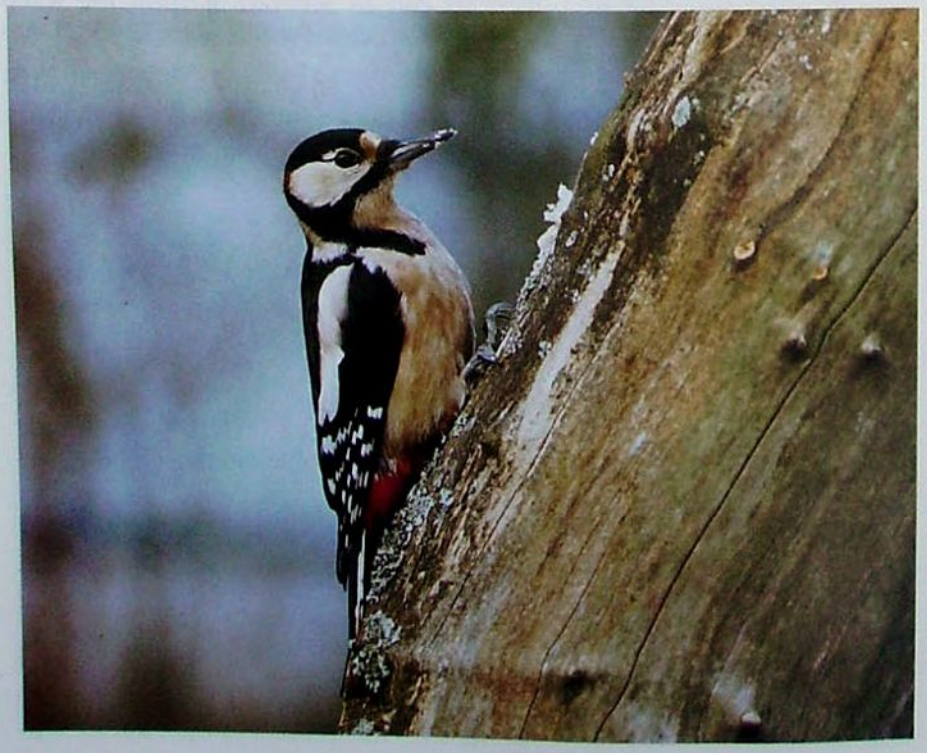
Riverside path Once more in the car, we continued following the Itchen until we saw a path leading away from the road towards the riverbank. We parked and followed this path to the water. The banks were flat and grassy with, on our side, a small grove of ash trees. We heard a whirring, high-pitched bird call, which Chris told me was that of a little grebe. Several of these small, rotund waterbirds came into sight, propelling themselves busily about on the surface of the fast-flowing river. I could hardly focus the binoculars on one before it dived–infuriatingly, the birds seemed to spend more of their time under the surface than on it.

On the landward side of the path was a hedgerow from which tall trees rose up at intervals. Chris noticed a marsh tit flitting from branch to branch in the trees, calling and then diving into the hedgerow. When it emerged to call again we saw that it was a neat little bird with a uniform black crown and light grey underparts.

Teal on the lake We drove on down the valley, pausing to count a total of 38 herons that had gathered in the neighbourhood of a fish farm. 'There could be another dozen out of sight somewhere,' was Chris's comment. Then we continued until we came to Avington Country Park, where the Itchen supplies water to an ornamental lake. We walked down to the lake; near the bank, the surface was interrupted with the scattered, brown stems of dead water dock. Among these plants and on the open water beyond, we saw teal, mallard, mute swans and coot, and it was the first of these that interested us most.

Above: It was nearing dusk of the short midwinter day when we arrived at the watercress beds, but in the short time available we saw both a meadow pipit (left) and a water pipit (right) which is a sub-species of the rock pipit.

Below: In the country park we occasionally heard calls of the great spotted woodpecker, and eventually saw two of these birds high up in a leafless oak. They were noticeable because of a conspicuous red patch beneath the tail. There were several bursts of drumming during the time we were in the park, but the woodpeckers we watched did not favour us with a performance.



With the binoculars we could easily see the splendid head markings of the male teal–brown with a stripe of vivid green. 'If you are not close up, you can't see the head clearly enough to recognise the teal,' Chris said, 'and the way to tell them then is by their yellow tails and by the white stripe on the folded wing, parallel to the water line. Also, teal are relatively small ducks.'

Watercress beds We turned back towards Alresford, making a last visit to some abandoned watercress beds, where Chris hoped to be able to show me some wintering redshank. Besides these, meadow and water pipits are often seen here, for the beds are good feeding grounds for birds, containing thousands of small snails, insects and other invertebrates. We walked down to the beds, and immediately saw an olive-grey bird rather like a small skylark, that uttered a 'seep' call. This call, the bird's pinkish leg colour and the olive colour of its back identified it as a meadow pipit.

Obligingly, a water pipit also came into view within a few minutes. This was darker grey, with dark legs; it had a white eye-stripe; and it gave a heavier, 'sseepp' call, louder and more emphatic than the thin call of the meadow pipit.

We left, for the winter light was failing. The redshank never did appear, nor were they the only birds we failed to find–we had nurtured hopes of fieldfares and redwings in the hedgerows, and nuthatches in the taller trees. We concluded that you have to take bird life as you find it–that way you appreciate the surprises better.

A NOCTURNAL MOTH-WATCH

The most effective way of finding out which moths live in your neighbourhood is to use their natural attraction to light. We join moth expert, Paul Waring, in an Oxfordshire garden on a November evening to discover how to use a moth-trap.

'Moth-trapping is like fishing,' explained Paul, 'the weather conditions must be just right, and once you have started trapping moths it becomes compulsive.' It was early in November, and we had been waiting three weeks for ideal weather to embark on our nocturnal moth-watch. What we needed was a mild, calm night and an overcast sky with a little drizzle. (The rain is important because it makes moths fly low, so they are more likely to be caught.) Tonight the rain was slightly heavy, but all the other conditions were fine. Paul explained that when conditions are absolutely perfect for 'mothing' then the moths flock to the trap. However such nights never occur more than two or three times a year.

Choosing a site We were standing in a wild garden in Oxfordshire which had been deliberately cultivated to encourage wildlife. By now it was almost dark–about six o'clock–but we could still see the outlines of hawthorn, blackthorn, a sallow tree, and a patch of stinging nettles–all foodplants used by moths of one sort or another. A garden in which there are plenty of native plants supports more species of moth than one which consists of predominantly alien plants.

I asked Paul what other factors should be considered when choosing a site for the moth-trap. 'A garden is adequate,' he reckoned 'but first you must check with your neighbour, as the light from a moth-trap is extremely bright and can be a nuisance.' He went on to explain that the moth-trap is best placed near a hedge (preferably one with a wide variety of plants) or among trees. Contrary to what might be expected, an open site is a bad idea, mainly because there is a scarcity of vegetation.

The first arrival Once we had positioned the trap and connected it to an electricity supply, we switched the light on. Within a few minutes our first moth had arrived. Approaching out of the gloom it fluttered near the trap for a short while before spiralling around the mercury vapour lamp and dropping into the trap after hitting one of the baffles. The moths caught by the trap remain alive and healthy and are released, unharmed, the following morning.

After fifteen minutes or so another two species arrived: the grey chi moth, a species commonly found resting on walls in the daytime, and a beaded chestnut moth. This last species can vary considerably in appearance from pale brown with specks to a uniform reddish brown.

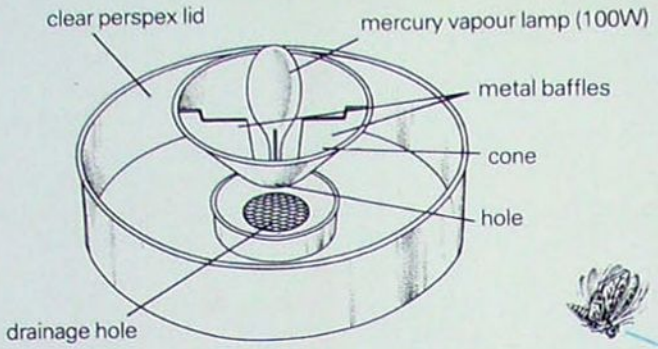
We had now been sitting around the moth-trap for an hour and, since there had been little activity in the last 20 minutes, we decided to leave the garden (the light still on) and wait until the following morning to see what we had caught.

Above: When you examine the catch, record each moth species in a notebook. Make sure you search the egg tray carefully and find every individual–some are well camouflaged against the grey papier mâché and can be difficult to see. After recording the moth release it under deep vegetation, or keep it in a cardboard box and release it the following evening.

Right: A single specimen of the silver-Y moth was caught. It can be recognised by the bright silver mark on each forewing. Unlike other moths caught in the trap, it flies during the daytime as well as at night.

The attraction of light

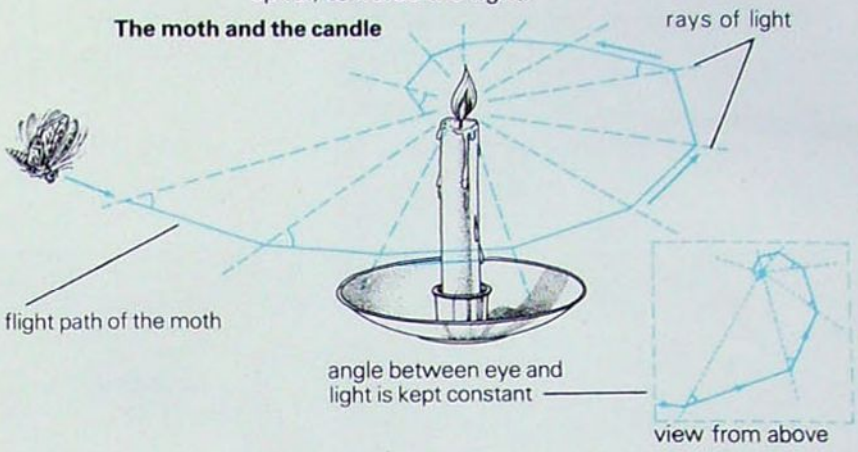
The Robinson trap



The Robinson moth-trap is one of the more popular types and relies upon the strong light produced by a mercury vapour bulb. This light contains ultraviolet rays which are known to attract moths better than ordinary white light. The base of the trap should be half filled with old egg trays to encourage the moths to settle.

There are many theories to explain why moths are attracted by lights, one of which involves moonlight. Since the moon is so far away, moths fly in a straight line if they keep its light at the same angle to their eyes all the time. If the same is attempted with a nearby light the moth's flight path is a spiral, towards the light.

The moth and the candle



Above: The angle shades moth is a common species in the autumn and it was not a surprise to trap one.

Below: An unexpected catch was the blood-vein which does not normally survive past late summer.

Moths at dawn At half past seven the next morning we returned to examine to catch. I had received strict instructions to arrive early so we could get to the moth-trap before the birds did. Many moths do not actually enter the trap, but rest on the surrounding grass and would be eaten by birds. Sometimes small birds, such as blue tits, actually enter the moth-trap–particularly if it is set up in the same place month after month. It was just as well we had arrived before the birds because, within seconds of turning off the light, we noticed a small moth resting on the grass, about a yard from the moth-trap. The moth's cream wings were open and the pretty, delicate pink vein running across them left us in no doubt of its identity. It was the blood-vein moth.

A short distance away Paul noticed another moth resting on the ground. This turned out to be another beaded chestnut, a very common species at this time of the year. We carefully moved around, looking in the surrounding grass and when we were confident that we had not missed any other moths on the ground we opened the trap.

Inside the trap Lifting off the lid we carefully examined it to check that no moths were resting there and then extracted the first egg carton. These are placed at the bottom of the trap to provide resting places for the moths. 'We've got an autumnal moth there,' Paul exclaimed. He added that the autumnal moth is a species, not just a moth that flies in autumn! A further look in the egg carton disclosed an ichneumon wasp, not a particularly welcome visitor as it parasitises moth and butterfly caterpillars. There were also a number of other insects, including dung flies and caddisflies–the latter obviously from the garden pond. Still examining the same egg carton we found a rather worn beaded chestnut moth and then another of the same species in slightly better condition.

On the next egg carton we found our fourth beaded chestnut and another autumnal moth. There was also an insect scarcely recognisable as a moth– the plume moth, *Emmelina monodactyla*. The last moth on this tray was a new species for the night–the red-lined quaker

which is only found in October and November.

There were quite a few specimens on the second tray. In one of the egg tray hollows we found a dark sword-grass moth which is a migrant from the Continent. It arrives here in spring and then lays its eggs on cabbage, lettuce or other low-growing plants upon which the caterpillars will feed and produce adults in summer. Paul thought the specimen we had caught was one of these native bred individuals as it was in good condition–individuals which have migrated tend to be rather battered. The next moth on the tray was the attractive grey chi moth–possibly the specimen we witnessed arriving the night before. The grey chi gets its name from a distinctive black mark on each forewing which is shaped like the letter chi from the Greek alphabet–a sort of curly X. The black and grey patterning of this moth made it quite difficult to see among the egg trays.

Next, we found two more beaded chestnuts which varied considerably from the ones seen previously. Paul mentioned that this species can range from pale brown to an overall reddish brown. With the addition of yet another autumnal moth the total for this tray was five individuals. The next tray sheltered a chestnut moth, a close relative of the beaded chestnut, and a moth called the satellite.

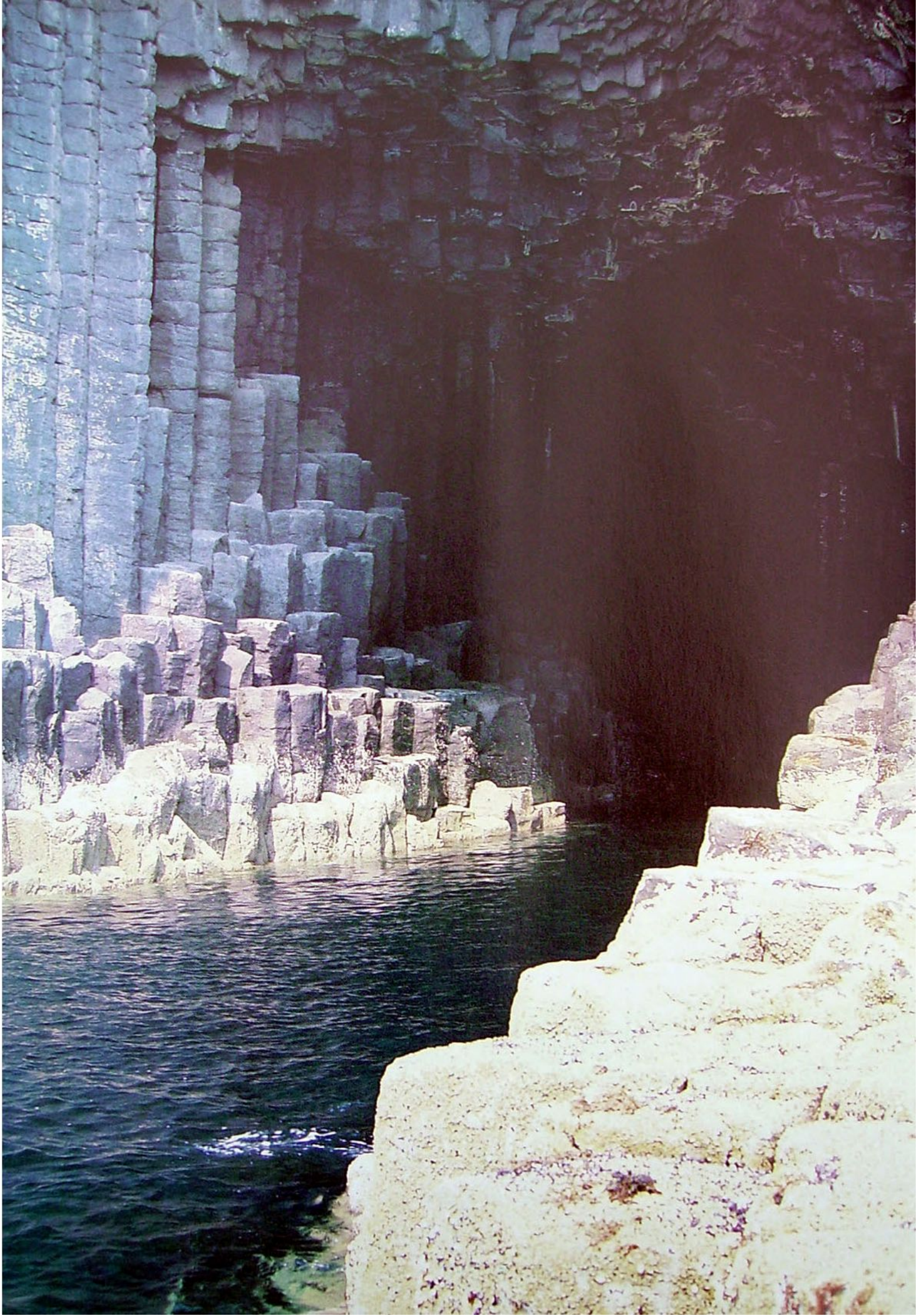
Above: A frequent capture in moth-traps at any time of year might be one of the many species of plume moth. They have a distinctive resting position, with their delicate wings furled and held at right angles to their body as shown here.

Finally we picked up the last tray to find two new additions to our list of species: the silver-Y, another migrant from the Continent; and the angle shades moth, a species which hibernates as an adult.

The catch had been examined and we had recorded the different species in our note-books, so the moths were released from the trap. Paul said that considering the time of year we had done very well to see 11 species.

Siting the trap

The vegetation of the site where you set up your moth-trap is especially relevant, since it determines the species you are likely to attract. The low-growing plants and garden flowers are foodplants for the caterpillars of the grey chi, angle shades, blood-vein, beaded chestnut, silver-Y, chestnut, and dark sword-grass. The autumnal moth and red-lined quaker depend upon trees such as sallow, while the satellite caterpillars feed upon elm. All these plants were present in our site.



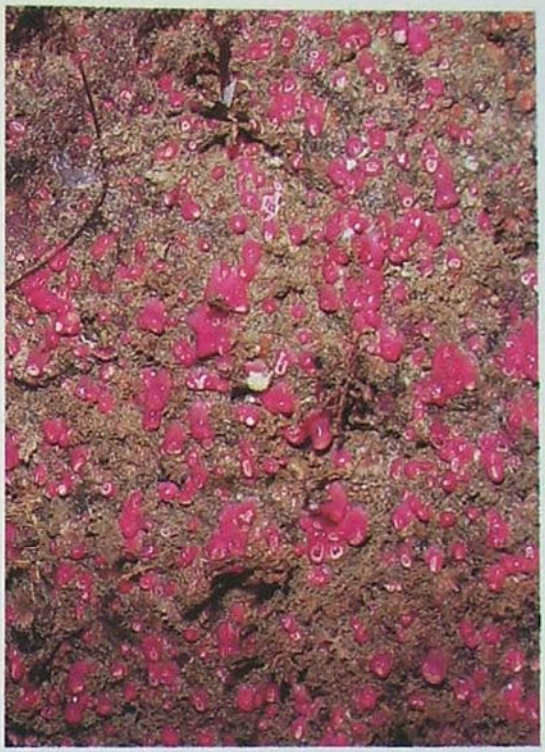
THE SECRET WORLD OF A SEA CAVE

Few creatures can survive in the dark, dank interior of a sea cave, but to those that can–particularly the seabirds and seals–there are considerable advantages, for a sea cave provides a degree of shelter and security hard to match elsewhere.

The life of a sea cave begins when the erosive power of waves breaking at the bottom of a cliff face exploits a weakness there and excavates a small hole. An obvious target for this process is a band of weak rock flanked by stronger material. Joints and cracks in a rock also allow a first exploring finger of erosion to begin its work. Sometimes the process is initiated by a rock-boring animal. In south-west England, for example, the common piddock slowly bores holes in the rock in which to live. If enough of these holes are bored the rock becomes considerably weakened and much more susceptible to erosion than the surrounding rock.

Once a weak point has been established, the pounding of the waves, and the erosive effects of sand grains, pebbles and even boulders being hurled against it, begin to gouge out a hole. Slowly the hole increases, and the bigger it becomes the greater is the effect of oncoming waves to trap air in it. The waves compress the air to such an extent that the release of pressure when the waves recede creates a vacuum that has almost an explosive power, further shattering the surrounding rock.

As the cave enlarges, blocks of rock periodically fall from its roof and eventually the roof is breached by a small hole leading up to the cliff top. If the hole is small enough the waves may force water through it in a dramatic spray. Slowly but surely the hole becomes bigger and finally the roof collapses–the cave has come to an end.



Right: A colony of jewel anemones exposed at low tide on the wall of a sea cave. The western part of the English Channel and south-west Ireland represent the northern limit of this species' distribution.

Opposite page: Fingal's Cave on the south-west coast of Staffa, Inner Hebrides. The dramatic appearance of this cave is due to the surrounding rock consisting of columns of basalt.

Below right: The chough is the rarest of our sea cave breeding birds and is now confined to remote coasts of Wales, Ireland, the Inner Hebrides and the Isle of Man. Its decline is probably due to its highly specialised feeding requirements–it eats ants and larvae in cliff-top turf, a habitat that is rapidly being converted into farming land.

Below: Carragheen, a species of red seaweed able to survive in the gloomy interior of a sea cave.

A sheltered spot The shape and size of a cave very largely determines the sort of wildlife that can survive there. For example, a small cave opening out into deep water has all the environmental harshness of an open cliff, and if it is being actively eroded then few forms of wildlife can survive the regular pounding by the waves. But a mature cave system, parts of which are now beyond the reach of eroding wave action, is a very special place. If such a cave is filled by the sea when the tide is in but exposed to the air during low tide then it becomes a similar habitat to that of a rocky shore. But there is one important difference–the rocky walls and roof remain damp, even

on the driest day, and they are sheltered from the frosts and snow of winter, and from the heat of the summer. The result is a particularly rich fauna with sea anemones, sponges, hydroids, sea mats and tubeworms forming a colourful, closely carpeted array on the cave walls. In the damp environment predatory snails and worms are able to remain mobile for long periods, even when the tide is out. Cracks and crevices in the cave walls provide a refuge for crustaceans such as the sea slater.

Plant life Deep inside the cave the air is moist and still, but there is little or no light. Therefore plant life is restricted to algae–slimes on the roof and walls and seaweeds in the water of the cave floor. The lack of light means that only the low-water red seaweeds, such as *Lithothamnion*, *Odonthalia dentata* and *Plumaria elegans*, can survive there, since they are better able to absorb the blue-green light needed for photosynthesis than are the brown and green seaweeds.

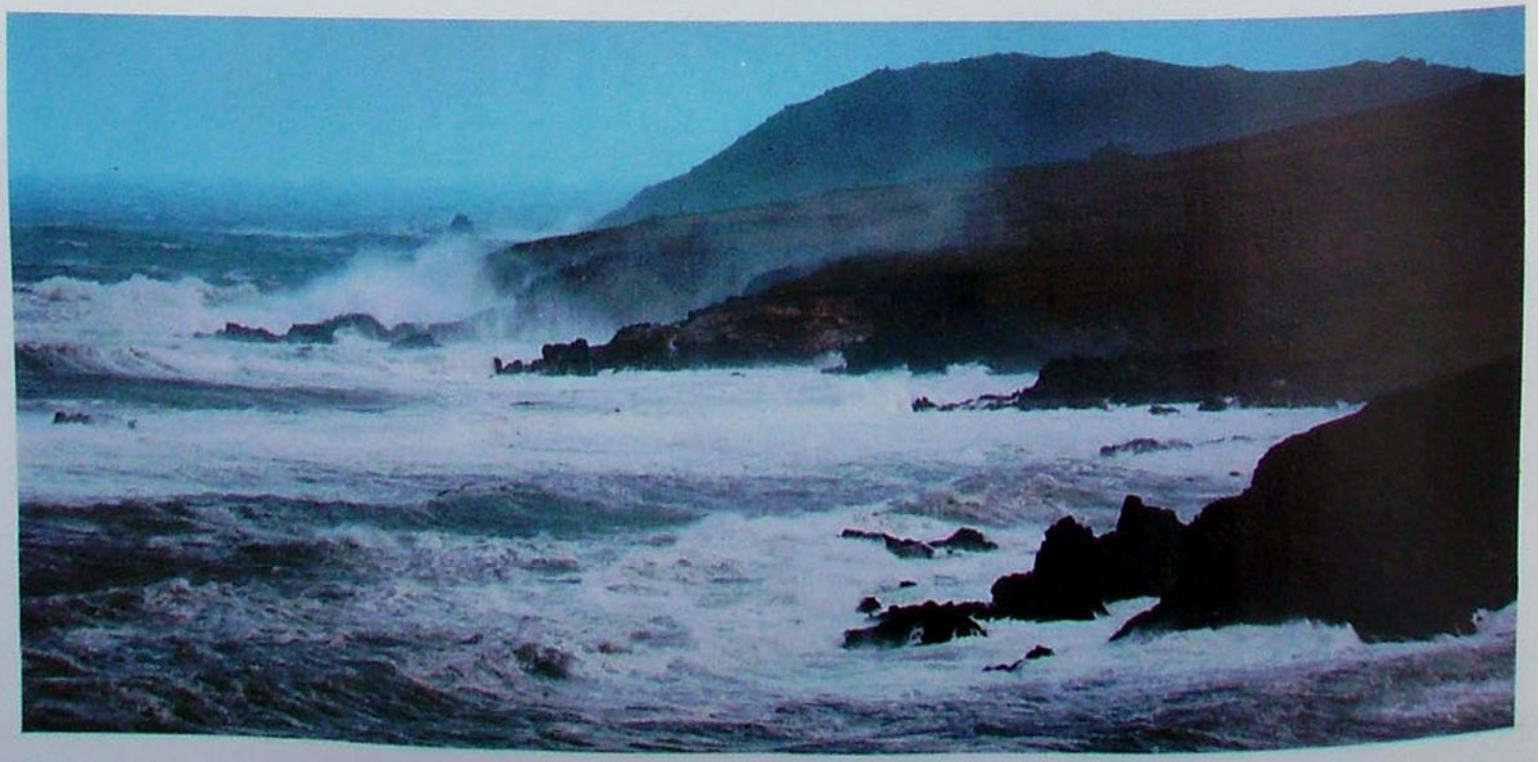
By contrast to the almost total lack of plant life within a cave, the entrance supports the same level of seaweeds as that found on a rocky shore. The entrance arches above the waves often have luxuriant displays of thrift, rock samphire, seabeet, plantain and campion, according to the season. Here these plants can flourish, situated as they are on a site quite inaccessible to foraging cliff-top rabbits.

Seals in a cave The shelter and security offered by a sea cave make them particularly attractive places for seals. The grey seal needs shelter from the pounding seas and minimal lack of disturbance at breeding time. Although the majority of the British population congregate on remote open beaches to drop their pups some seals regularly use caves in the Welsh islands such as Skomer for this purpose.

Above: A grey seal pup at the entrance to a cave. For a seal the ideal cave is remote with a patch of dry sand at the back, out of reach of high tide. It also has some underwater exits and entrances via which the seal can leave and enter the cave unobtrusively.

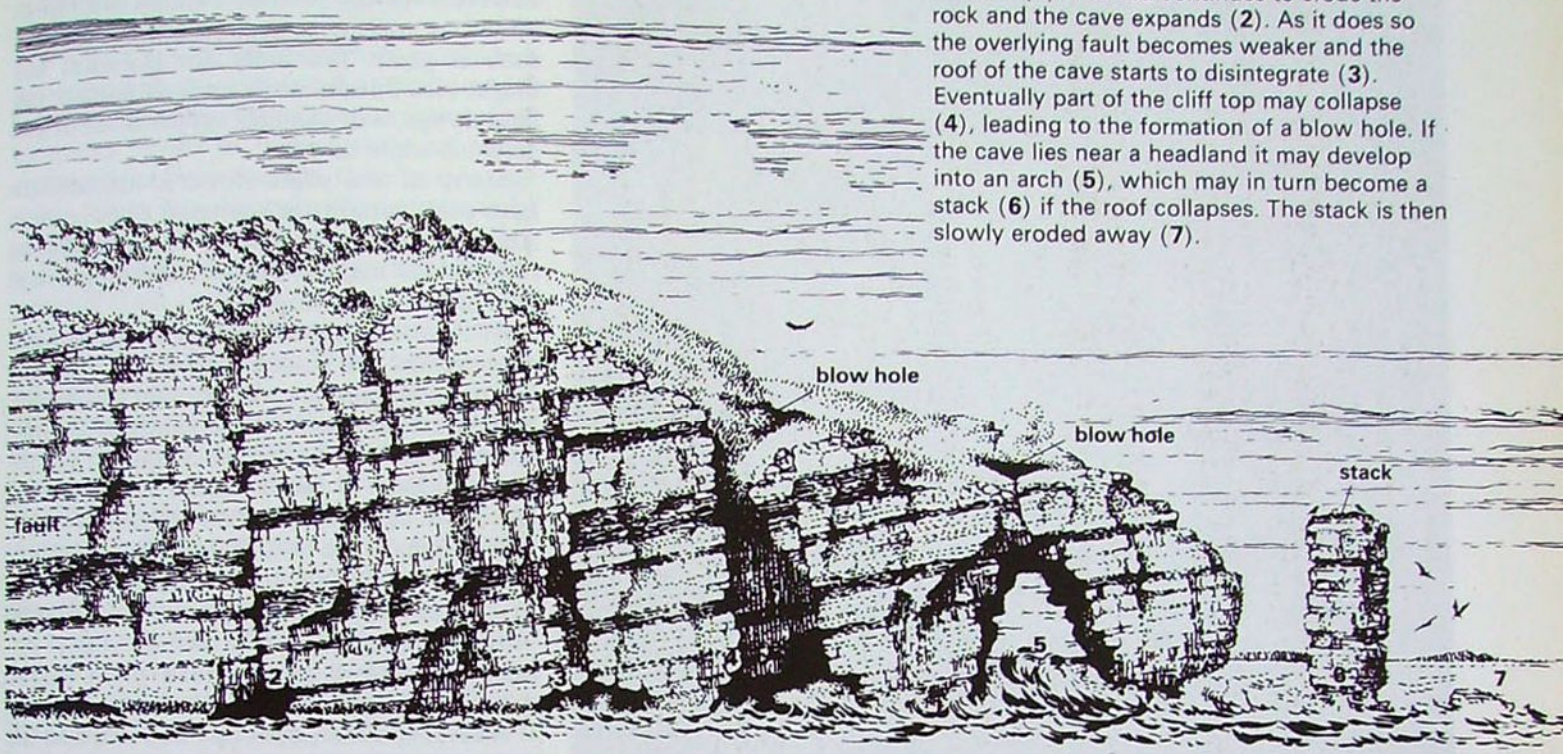
Below: Given a weak point in a cliff face the pounding of the sea will gradually wear away the rock at that point and begin the formation of a sea cave.

To be suitable such a cave needs to be extensive enough to offer a patch of dry beach inside–and it has to remain dry even at high water. This is where the pup will be born and perhaps stay for up to a month, suckled by the mother. At birth the fluffy, creamy-yellow pup weighs about 15kg (33lb) but after suckling for a month or so on its mother's extremely rich milk it is likely to weigh close to 50kg (110lb). The blubber-clad youngster then leaves the safety of the cave and its mother and heads out to the open sea. A cave system that has a deep water entrance as well as a patch of dry sand is particularly attractive to seals, for it provides them with secret escape routes safe from human disturbance–man



The history of a sea cave

The first step towards the formation of a cave is the sea undercutting the cliff face at a weak point, for example a vertical fault at the base of the cliff (**1**). The sea continues to erode the rock and the cave expands (**2**). As it does so the overlying fault becomes weaker and the roof of the cave starts to disintegrate (**3**). Eventually part of the cliff top may collapse (**4**), leading to the formation of a blow hole. If the cave lies near a headland it may develop into an arch (**5**), which may in turn become a stack (**6**) if the roof collapses. The stack is then slowly eroded away (**7**).



1 Cliff is undercut at base of fault | 2 Erosion increases size of cave | 3 Fault is further weakened and fault collapses | 4 Cliff top subsides creating a blow hole | 5 Continuing erosion creates an arch | 6 Roof of arch collapses leaving a stack | 7 Stack is weathered away

being their only enemy in Britain.

Bird residents The young seal born in a cave lies in almost total darkness deep within the cliff, but the birds that choose to roost and breed there do so close to the entrance. As with seals, birds are attracted by the security, shelter and remoteness of caves.

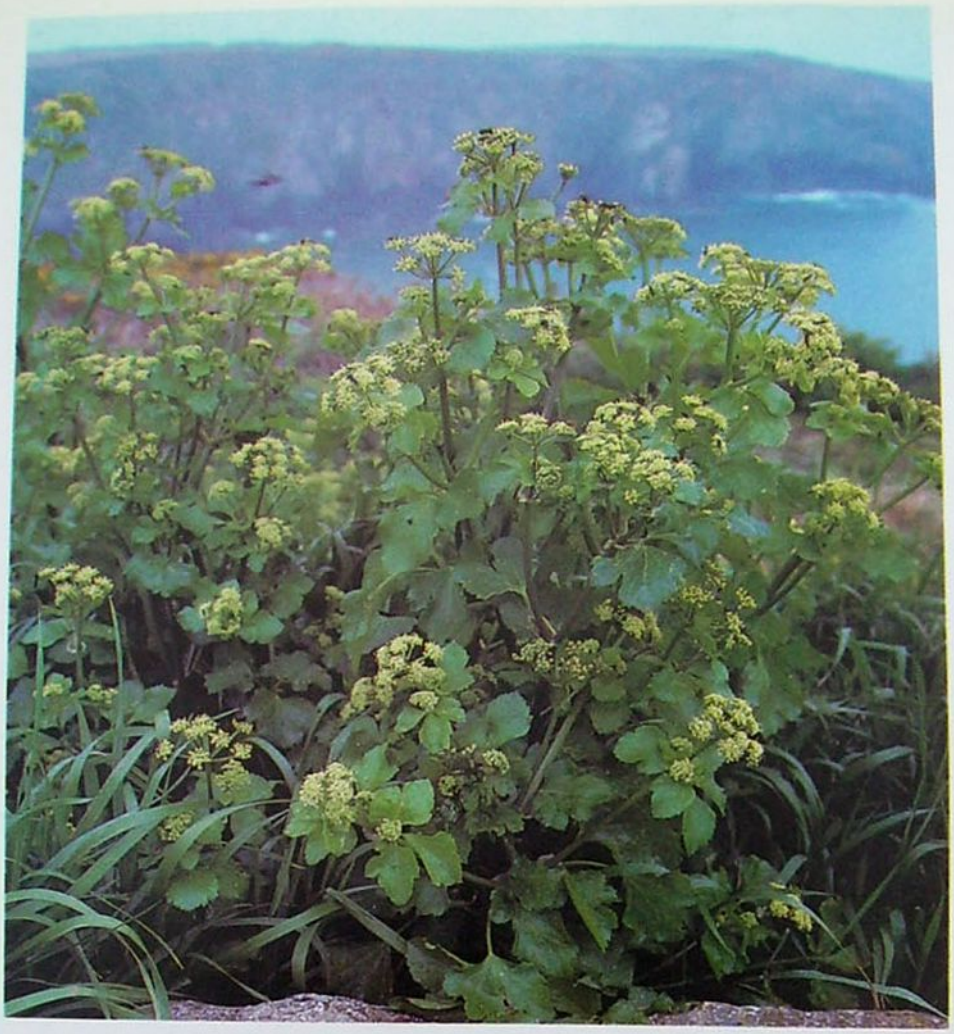
Once, rock doves were the typical residents of sea caves, but now they are by far our rarest species of pigeon, surviving only on remote coasts and islands in Scotland and Ireland. These birds rear their young on rocky nesting ledges. Because they can feed these fat squabs on pigeon's 'milk' they do not need to rely on the seasonal availability of food and so are able to produce offspring throughout the year. The young squabs were once gathered by coastal people as a valuable source of meat during the winter months.

Today almost all the pigeons lining the cave ledges to breed and roost are feral birds, many being ex-racing pigeons still bearing their rings. Sunny south-facing ledges, with foraging on the cliff-top and nearby shelter of the cave when necessary, is an easier prospect than the rigours of long-distance racing, and many opt for this more natural life-style and are now flourishing. The success of the feral pigeons is now being checked somewhat by the resurgence of the peregrine falcon, whose main source of food around the coast is seabirds and pigeons.

Another cave breeding bird, the chough, is now very rare indeed. The remote coasts of Ireland, Wales, the Isle of Man and the Inner Hebrides are today its only strongholds in the British Isles.

Fingal's Cave One of the most famous sea caves in the world, and certainly the most spectacular in Britain, is Fingal's Cave on the Isle of Staffa in the Inner Hebrides. At its mouth it is 13m (40ft) wide and 20m (66ft) tall, from sea level to roof. It also extends about 8m (25ft) down into the sea and goes back into the cliff for a distance of more than 60m (200ft). Fingal's Cave–immortalised by the composer Felix Mendelssohn who named an overture of 1829 after it–is aptly known as the Cathedral of the Sea.

Below: One of the ways in which a cliff face can be weakened, and thus become susceptible to erosion, is by the action of a creature called the common piddock. This bivalve has sharp teeth on the edges of its shell. By twisting itself from side to side it slowly drills a hole into the rock. Several holes can be seen in this picture. By the time a piddock reaches maturity it will have drilled itself as far as 30cm (1ft) into the rock.



FLOWERS OF THE CARROT FAMILY

At first the carrot family appears to be a formidable group of white flowered species impossible to tell apart. Yet many of the species have pink, blue, yellow or green flowers–and all can be identified by closely examining their fruits.

Most of us are familiar with the very common umbellifers–as members of the carrot family are called- found in country lanes and along roadside verges, from spring, through to as late as early winter. Species such as hogweed, fennel, cow parsley (sometimes known as Queen Anne's lace), wild carrot, wild parsnip, upright hedge parsley and groundelder are distinct and recognisable to anyone walking in the countryside and paying attention to the surroundings. But the seven plants mentioned above represent only about a tenth of the various species that are to be found in Britain as natives or naturalised aliens.

Colours of the rainbow All umbellifers have flower heads of the compound umbel form, that is to say they consist of a number of branches radiating from the top of the main stem and bearing small flowers. Not all the flowers are white as is commonly believed, however. All the primary colours are represented as well as several secondary colours such as green. Sea holly, for instance, has bright blue flowers while its rarer cousin, the field eryngo, is of a similar appearance but has greenish-white flowers.

Many of the white flowered umbellifers have pink variants in scattered populations. Among these are the greater burnet saxifrage (*Pimpinella major*), upright hedge parsley, wild angelica and hogweed.

At the other end of the spectrum there are many yellow and golden flowered umbellifers. The most familiar are wild parsnip and fennel, both common plants in the south of Britain. Another yellow umbellifer found in south-east England is hog's fennel (*Peucedanum officinale*), otherwise known as sulphur weed. This species is the only foodplant of the rare swallowtail butterfly. Probably the most striking umbellifer, though sadly not native, is yellow thapsia (*Thapsia villosa*), again occasionally grown as a garden plant in the milder counties.

Another colour possibility is green, and the flowers of alexanders fit this group with their yellowish-green umbels. This is a striking plant, easily recognisable from other British umbellifers by its enormous red-veined leaf bases and shiny black fruits. It was probably introduced as a pot herb many centuries ago and is now found along roadsides and rivers, particularly near the sea; it occurs as far north as the Firth of Forth in Scotland and is most plentiful along the east coast.

Identifying with fruits The fruits of umbellifers are extremely variable and if you take time to examine them carefully you will soon

Above: Alexanders (*Smyrnium olusatrum*) is a striking plant with yellowish-green flowers and enormous red-veined leaf bases. Although this species is now common along roadside verges and rivers in coastal areas it is an alien, having been introduced for cultivation as a herb years ago.

Right: The delicate pinkish-white flowers of wood sanicle (*Sanicula europaea*) can be seen from May to August growing in deciduous woodland.

find easy ways to identify them. Umbellifer fruits can be roughly divided into major categories: long and slender so that their length is at least two or three times their width, or short so that they are more or less as long as they are wide.

Within these categories further groups can be recognised: smooth and flattened, smooth but longitudinally ribbed, surface interrupted by spines, hooks or bumps; there are many intermediate forms within these major divisions. These are the main characteristics by which botanists have separated the various genera in the Umbelliferae over the centuries.

Round fruits Hogweed is a good example of a round-fruited umbellifer; its fruits have a smooth flattened surface. When ripe you can see they consist of two equal halves; each is known as a mericarp and contains just one seed. The mericarps are joined together by a thin strand of tissue usually referred to as the carpophore. At the top of each mericarp is a slightly swollen area from which a withered style protrudes bearing the stylopodium, a disc which secretes nectar.

The largest part of each mericarp is taken up by a seed, but sometimes an area between it and the stylopodium can be distinguished. This is known as the beak–it is not present in hogweed fruits, however. A distinctive feature about hogweed fruits is the presence of oil canals (vittae) which appear on the surface as brownish lines; two of these are clearly visible.

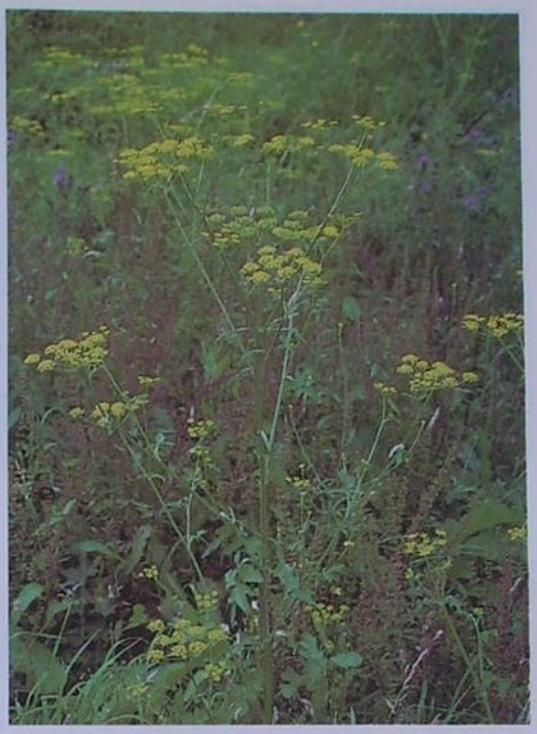
Elongated fruits At the other extreme is shepherd's needle (*Scandix pecten-veneris*) which bears fruits of the long, narrow type. These fruits have ribbed mericarps and extremely long beaks so that the entire fruit may be 3-7cm (1-2¾in) long. Although the foliage of shepherd's needle is similar to that of some other umbellifers the needle-like fruits make it instantly recognisable.

Somewhere in between these two categories, in terms of fruits, is sweet cicely (*Myrrhis odorata*), a large perennial herb confined to the north-west of the country where it is often found along streams and river banks. This species has elongated fruits reaching 1.5-2cm (½-¾in) long which are instantly recognisable by their shiny black surface, deep ridges and strong smell of aniseed when crushed.

Spiny fruits So far we have dealt with variously ribbed, elongated and rounded fruit types but the most interesting are those with different protuberances. These are most developed in such species as carrot and hedge parsley. Of these the knotted hedge parsley has the most diverse fruits, for each mericarp in any pair is different. The outer mericarp has radiating spines, often with hooked tips, while the inner mericarp is covered with tubercles (small rounded projections).

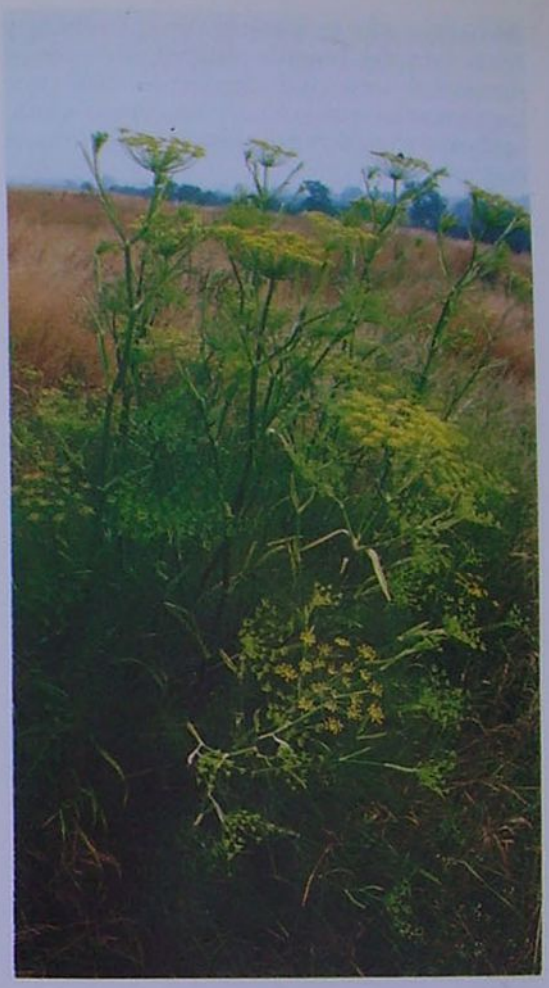
Wild carrot also has spiny mericarps, but these tend to be more orderly in their arrangement than those of knotted hedge parsley. The spines are confined to the

Right: Wild parsnip is one of our more familiar yellow flowered umbellifers. It is fairly widespread in southern and eastern England, growing in hedgerows, along roadside verges and on wasteland. The flowers can be seen in July and August.



Below: The flowers and fruits of wild carrot (*Daucus carota*), an umbellifer with a distinct carrot-like smell. When the white flowers have been fertilised the umbel (flower head) closes up–as can be seen in the right-hand specimen in this picture.

Bottom: The spiny fruits of wild carrot make this species easy to distinguish from other umbellifers.



secondary ridges while the primary ridges are covered with rows of hairs. These features, combined with a distinct carroty smell and broad white umbels which often have a purplish black flower in the centre (a device to attract pollinators), make wild carrot a very distinct species.

Both knotted hedge parsley and wild carrot prefer dry, sandy soils and are often found on waste ground. The spiny fruits are thus very useful when it comes to dispersal, for they become attached to passing birds or mammals. Although not related, sea holly also has spiny fruits which are dispersed by animals. It belongs to a different subfamily within the umbellifers.

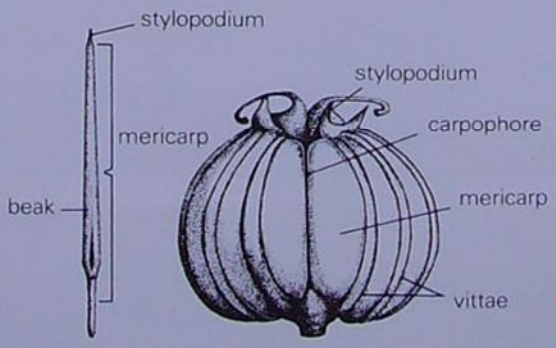
Above: The greenish-white flowers of field eryngo (*Eryngium campestre*) are now a rare sight for this species occurs only along the coast of Cornwall, Devon, Hampshire and Guernsey.

Right: Fennel (*Foeniculum vulgare*) is only doubtfully native in this country; for many years it has been cultivated as a food flavouring, and may well have been introduced to Britain for this purpose. Now it thrives particularly along motorway verges.

Identification by fruits

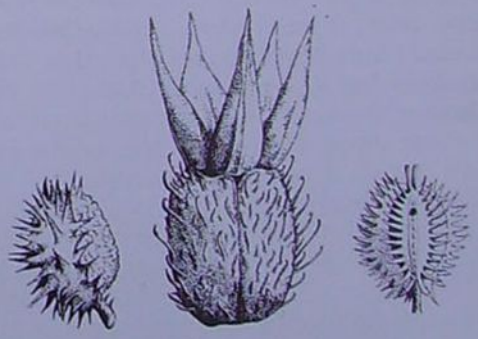
Umbellifer fruits have two mericarps, each containing one seed, joined by some tissue–the carpophore. Protruding from the top of each mericarp is a withered style and a stylopodium. In some fruits there is an area between this and the part of the mericarp taken up by the seed known as the beak. The vittae are oil channels.

Typical fruit structure



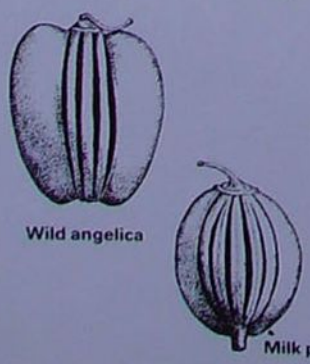
Shepherd's needle Cowbane

Spiny fruits



Knotted hedge parsley Sea holly Wild carrot

Ridged fruits

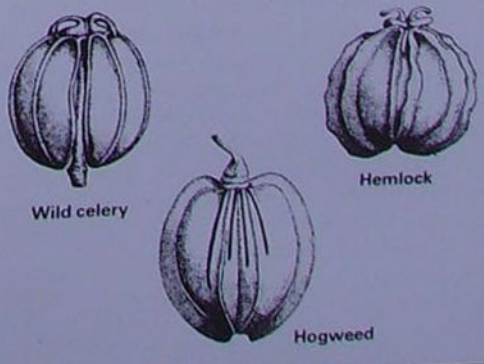


Wild angelica Milk parsley Caraway Sweet cicely

Elongated fruits

Shepherd's needle

Rounded fruits

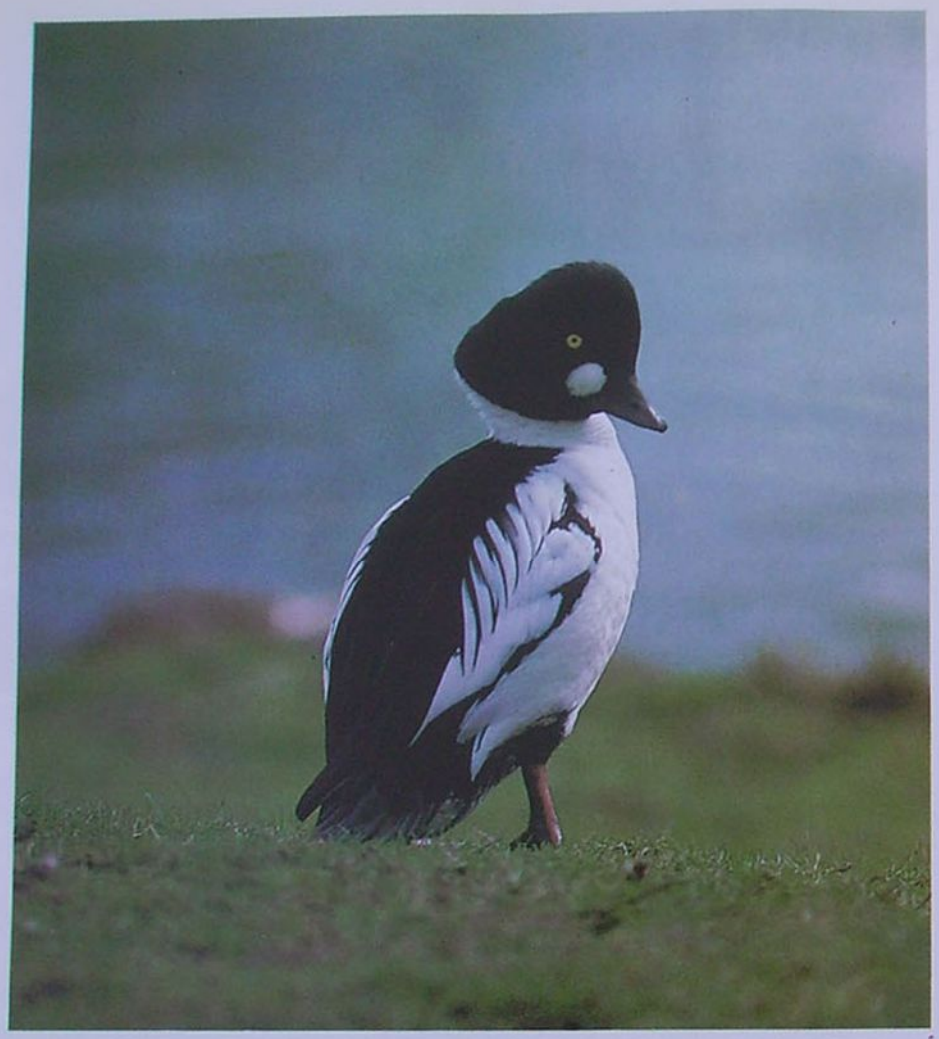


Wild celery Hogweed Hemlock

Umbellifer field guide

Identifying the different species within the vast umbellifer family may seem a daunting task initially for many of the flowers resemble one another; their flower heads are of the compound umbel form which consists of a number of branches bearing several flowers. The clues to identification, however, often lie in the leaves and fruits. Below are seven representatives of the umbellifer family which you are most likely to come across, together with their fruits.

1 Hogweed (*Heracleum sphondylium*).
2 Wild angelica (*Angelica sylvestris*).
3 Groundelder (*Aegopodium podagraria*).
4 Rock samphire (*Crithmum maritimum*).
5 Upright hedge parsley (*Torilis japonica*).
6 Rough chervil (*Chaerophyllum temulentum*).
7 Marsh pennywort (*Hydrocotyle vulgaris*).



PIEBALD SMEW AND GOLDENEYE

Above: The male goldeneye: thick black plumage on the neck and crown, plus a black bill, give its head a distinctly triangular appearance.

Below: A pair of smew–the male is on the right.

Smew and goldeneye are two piebald ducks that are seen on reservoirs and other man-made waters when wintering in the British Isles.

Smew and goldeneye are both diving ducks. The smew, a fish-eater, is in the same genus (*Mergus*) as the mergansers, while the goldeneye, living on insect larvae and molluscs, has similarities with the scoters.

Thin black stripes The word 'unmistakable' should always be used with caution in bird identification, but for the smew it is appropriate at all times. The highly distinctive male is predominantly white, but has a certain amount of black patterning: there is a small black patch round the eye extending forwards to the bill, another patch of black at each side of the nape, and a network of thin black lines along the back and flanks, two of which form an inverted V on the sides of the chest. In flight, the amount of white is less striking, with black outer wings and back, and a grey stern.

The adult female smew, and first-winter birds of both sexes, are mainly grey, darker above than below, but with pure white cheeks topped by a chestnut crown. In flight, there is a broad white wing bar, while the white cheeks are particularly noticeable.

Rare winter visitors Smew are regular winter visitors to Britain, but only in very small numbers. Their breeding grounds lie in the forested regions of northern Scandinavia and the Soviet Union, from where the birds migrate to central and eastern Europe: altogether they number about 75,000 individuals, but Britain lies right on the edge of their winter range, and so receives only a tiny proportion of this number.

In normal British winters the peak count rarely reaches 100, with almost all the birds concentrated in the south-east of England. The best places to find smew are on the various reservoirs in and around London, and on lakes and gravel pits in Kent, especially in the south-east corner around Dungeness. Hard winters bring influxes from the Continent, but even then numbers are small. In the cold winter of 1978-79, for example, the total reached 380.

Fish eaters Smew are expert divers, obtaining nearly all their food under water. It consists mainly of fish, though smew also take large aquatic insects. They submerge for an average 30-45 seconds and probably dive no deeper than 4-5m (13-16ft). They eat quite small fishes, mainly 3-6cm (1-2½in) long, but have occasionally been recorded as taking much larger prey–up to 10cm (4in) or exceptionally 20cm (8in) in length.

Big-headed goldeneye The goldeneye is a dumpy duck, with a noticeably large, rounded head. The male is principally black and white:

its head is black, glossed with green, and there is a bold round white patch just in front of the eye. The back and tail are black, and the chest and flanks are pure white. In flight, the large head is prominent, and the bird is conspicuously piebald because the outer half of each wing is black while the inner half is white.

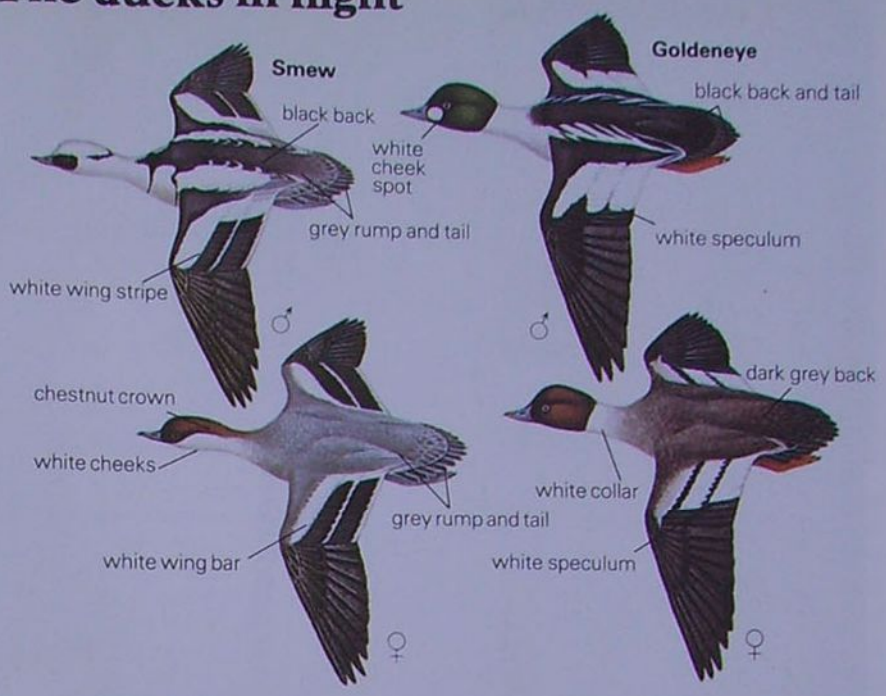
The female is much duller, being dark grey-brown above, and much paler below. The head, also large and rounded, is dark brown, and there is a broad white collar round the neck. Her wing pattern in flight is similar to that of the male. Both sexes have a golden yellow eye, which can be seen at a considerable distance.

Breeding in Britain A very small number of goldeneye pairs breeds in Britain. The world-wide breeding range extends right across the northern parts of Europe and Asia, and across much of North America. The breeding habitat is always forest, usually coniferous, and nests are close to still or running water.

The history of the British breeding population of goldeneye is a recent one. Occasional breeding was reported in the 1930s, but it was thought that this may have involved injured birds that were unable to migrate back to their normal breeding areas. During the 1960s nestboxes were erected in suitable areas in northern Scotland, in the hope that birds wintering in the area might be encouraged to stay and breed. This hope was fulfilled in 1970 when a female was seen with ducklings at a site in Inverness-shire. Since then there has been a small but steady growth in the number of nesting pairs, nearly all of them in nestboxes. By 1983 they had increased to 24.

Wintering goldeneye The small number of breeding goldeneye is joined for the winter by some 10,000-12,000 birds from breeding grounds in Scandinavia and western Russia. These spread throughout the British Isles. One feature of our wintering flocks is that females generally outnumber males considerably. This is because more of the males are wintering further to the east and north. In the Baltic countries, for example, there are many more males than females. It may be that the males, being a little larger, are more hardy than the females, and therefore better able to spend the winter in colder areas. Also, they start their autumn migration ahead of the females, having no family duties to carry out, and when the females arrive at the Baltic wintering grounds they find them already rather full of males, so that the bulk of them move on further south and west.

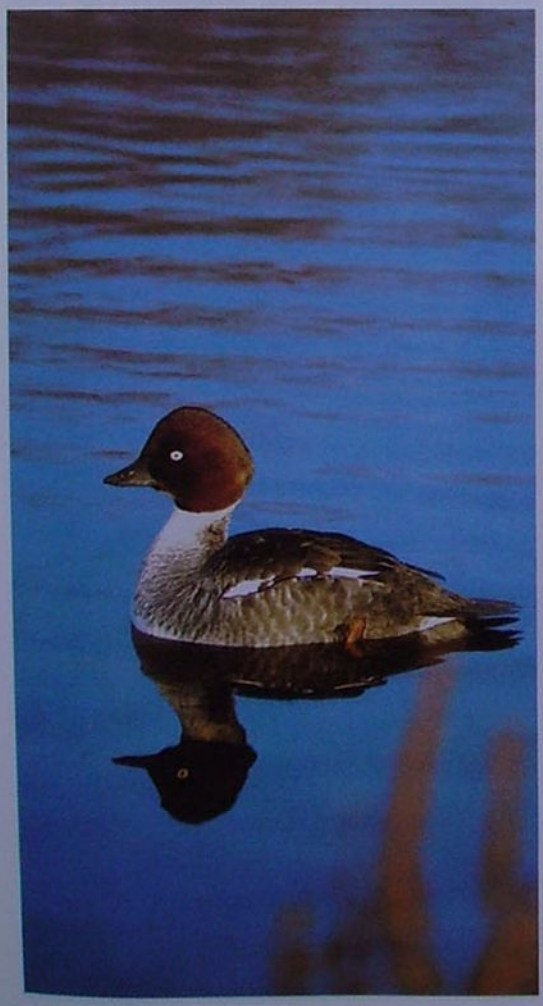
The ducks in flight



Smew (*Mergus albellus*). Rare winter visitor; 43cm (17in).

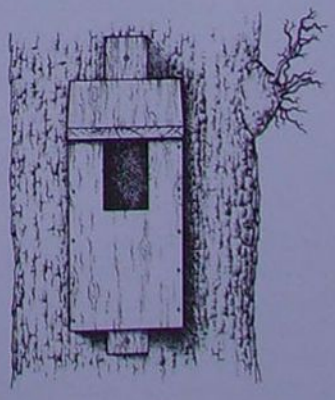
Goldeneye (*Bucephala clangula*). Scarce resident, common in winter. 46cm (18in).

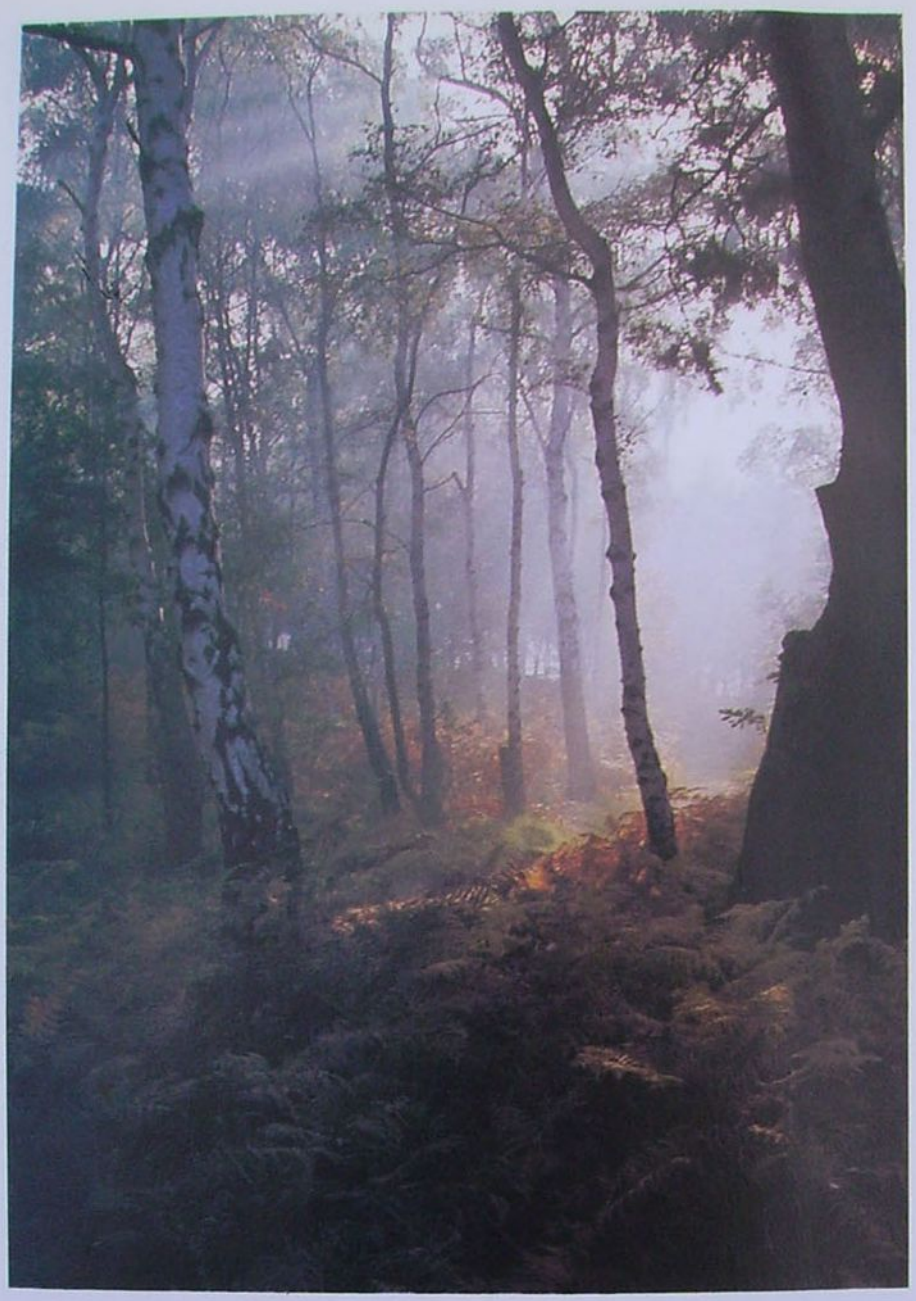
Left: The female goldeneye has a brown head.



A nestboxing success

The natural nest-site for a goldeneye is a hollow in a tree, not (as in smew) an abandoned woodpecker hole. Under commercial forestry, with felling and replanting, it takes years before trees are old enough to have natural holes. Fortunately, these birds willingly use nestboxes, and so an RSPB nestboxing scheme enabled them to colonize Scotland.





BIRCHWOODS OF BRITAIN

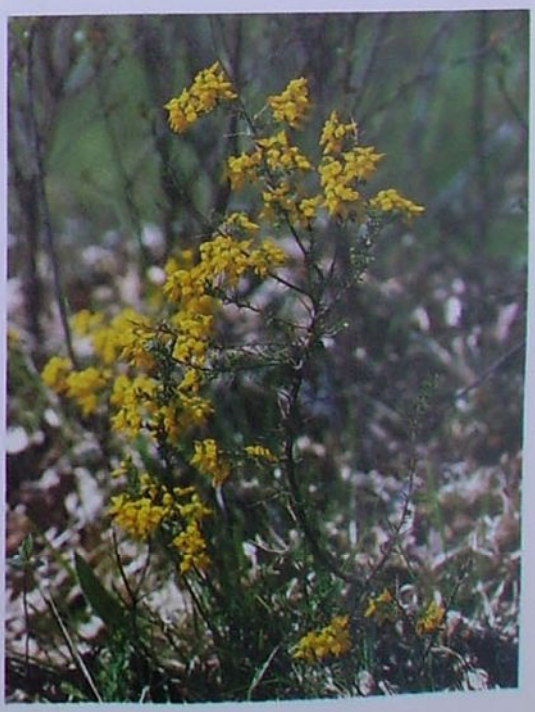
The steep hillsides of the Scottish Highlands are colonized in many areas by downy birch. On the lighter, drier soils of south-east England silver birchwoods are more common. Both habitats support a variety of animal and plant life.

Birches are among the world's hardiest trees, growing in forests all round the Northern Hemisphere right up to the edge of the tundra. They are abundant in temperate regions also. Out of a world total of about 40 species, three birches are native in the British Isles: dwarf birch–a very small shrub of high Scottish moorlands occurring only locally; and two tree species, downy and silver birch, both of which are widespread and common. Of these the downy is slightly hardier than the silver birch and is the dominant birch in the cold wet areas of upland Britain, especially in the Highlands.

At the end of the Ice Age birch and pine were the first trees to advance north into Britain and form forests. Then, as the climate continued to improve, these two species were largely replaced by forests, mainly of oak, until eventually birch and pine were dominant only in the cooler climate of the Highlands. Remnants of these forests show that while pine defeated birch on the richer Highland soils, birch survives where pine fails on poorer soils. Where, as often occurs, the soils are mixed, pine and birch grow side by side.

Woods almost purely of birch flourish on many Highland glensides up to about 600m (2000ft). Few other trees grow among them, but by far the commonest is rowan. Of vast extent in early prehistoric times, these woods have been declining ever since Neolithic man began to destroy them and prevent their regeneration by the introduction of grazing animals. The surviving birchwoods of Scotland vary greatly. A few consist of fine, well-grown trees–though never as magnificent as those of Scandinavia. Where conditions are harsh the woods are made up of contorted, diseased and insect-ridden trees not reaching 6m (20ft) in height. The usual end of such degenerate woods is to be gradually destroyed by gales.

How the birch spreads Birch is an eager colonizer. Its multitudinous seeds are small and light and may be carried far by the wind. So in the absence of grazing animals, birchwoods can develop on wet or dry grasslands, peaty or sandy heaths and commons, sites of



Above: Esher Common near London where silver birches flourish. Petty whin (right), lesser twayblade and chickweed wintergreen are some of the choicer species of wild flowers that grow in birchwoods.

felled woodland, screes and even the infertile waste-tips of collieries and slate quarries. At first the seedlings may be crowded together but they soon eliminate their weaker numbers by competition until, by the time the survivors develop into mature trees, they are usually well spaced. There are two reasons why they do not grow close to each other: during gales their tough whippy branches lash at neighbouring trees; and below ground there is similar intense rivalry as each tree's hungry roots spread widely near the surface and challenge those of other trees.

While downy birch is commoner in upland Britain, silver birch is characteristic of the lighter, drier soils of south-east England, except those on chalk which contain too much lime for either species. These ecological differences are, however, only slight. Very often the two grow in the same wood. And even in the Scottish Highlands, especially in the east, there are woods of silver birch; while there are occasional woods dominated by downy birch in the south of England, particularly on wetter soils.

In the colder parts of the Northern Hemisphere birch makes climax forest. In the mild climate of much of the British Isles birch competes with temperate-zone trees and a birchwood here is usually a transitional stage in the formation of a different kind of wood. While still in its early stages it may be invaded by oaks as jays bring acorns, bury them among the birches and then forget them. Eventually the birches are smothered by the growing oaks (or by beeches, pines, sycamores and other large trees). Conditions are more favourable for the birchwoods high in the Scottish Highlands, because at many sites the conditions are too harsh and infertile for rival types of woodland to challenge birch.

At first sight the larger Scottish birchwoods may seem like relicts of climax forest. Yet if we could observe them over a long enough period we would probably find that they are far less permanent. A birch lives only 70-80 years and birchwoods seldom show signs of active regeneration within the wood. Often there are no young trees at all and the old trees all look about the same age, suggesting that they colonized the site when the area was not being grazed for a few years. So it may be that even in the Highlands the birchwoods are always on the move, here this century but gone the next.

Above: A family of birch shieldbugs–a female and nymphs. The other shieldbug found in birchwoods is the parent bug, famous to entomologists because the female has a habit rare among insects: she stands on guard to protect her progeny.

Below left: Boletus fungi, such as this brown birch bolete, are common in birchwoods and are usually found close to the base of the trees.

Below: The stoat lives in a wide range of habitats including birchwoods. Another carnivore, the wild cat, roams over Highland birchwoods, and where pines grow among the birches the pine marten may also be present.

Woodland layers Because the trees are usually well spaced, light reaches the floor easily, so provided grazing is not too severe (few birchwoods are fenced) there may be well developed field and ground layers. On the impoverished acid soils of Scottish hillsides the vegetation under the trees is usually poor in species, frequently consisting of spreads of bilberry, crowberry, heather, wavy hair-grass or bracken, and occasionally a dense shrub layer of juniper.

Squeezing in here and there amongst these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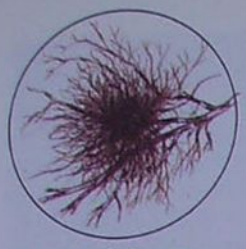
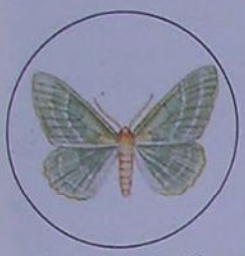


1 witch's broom

2 long-tailed tit



3 large emerald moth

4 willow warbler

5 birch sawfly

6 redpoll

7 moss
Hylocomium splendens

8 fly agaric

9 lesser twayblade

10 wood sorrel

Left: Some of the plants and animals you can find in a birchwood. Right at the top of the **tree layer** are dense clusters of twigs known as witch's broom. When there are many in one tree they look like a number of untidy rooks' nests. They can be caused by a fungus or a mite and are thought to be connected with an upsetting of the tree's hormone balance. In summer you might see the beautiful large emerald moth, though its delicate green colour makes it difficult to spot among the leaves. Its twig-like caterpillar feeds on birch leaves. Another insect found high up among the trees is the birch sawfly, whose white caterpillars are easily seen feeding on the leaves. The adult flies slowly around the trees rather than settling on the leaves. Among the birds of the tree layer are the insect-eating willow warbler and the seed-eating redpoll, as well as the more omnivorous long-tailed tit. Down in the **field layer** wild flowers such as lesser twayblade and wood sorrel grow with mosses such as *Hylocomium splendens*, while several fungi are particularly associated with birchwoods, the most striking being the fly agaric.

Below: Surprisingly, no butterfly larva eats the leaves of birch; but very locally Scottish birchwoods are the habitat of the rare chequered skipper whose foodplants are woodland grasses. It flies in late May and June.

dominant species are such wild flowers as yellow tormentil, white heath bedstraw and heath milkwort, which has flowers that may be pink, blue or white. There are many mosses, the great carpeters being those which also spread widely over the ground in the nearby woods of pine and sessile oak: *Rhytidiadelphus loreus, Pleurozium schreberi* and *Plagiothecium undulatum*, for example.

Though our birchwoods are rich in edible fungi, few people eat them. Yet every autumn in the Continental birch forests they are gathered to be dried and kept for winter eating. One that is definitely not to be eaten is the spectacular scarlet-capped, white spotted fly agaric. This is one of several fungi whose mycelia live in intimate association with the root tips of birches. Among others are ugly milk-cap, coconut-scented milk-cap and brown birch bolete.

Animal life Since birch has been so abundant over a vast reach of time it is inevitable that many insects have become adapted to a birchwood existence. Thus there are more than 120 kinds of larger moths which live on birch, a figure exceeded only by those on oak. Most of these birch feeders live on other species as well, oak especially, as is natural since birch and oak so often grow together. And some moths such as the mottled umber defoliate birches just as efficiently as they strip the oaks.

While no mammals or birds are peculiar to British birchwoods many species found in other woodlands also live there. The most distinctive mammals are red and roe deer in their seasonal wanderings, and wild cats whose numbers are gradually increasing. In woods of birch mixed with pine, another rare mammal, the pine marten, finds shelter. Typical summer birds of these Highland woods are chaffinch, willow warbler, tree pipit, robin, redstart and various tits, and occasionally redwings. All over the British Isles birch seed is a major food of finches, especially flocks of redpolls and siskins which take the seeds off the trees in autumn and from the ground in winter. Woodpeckers, jays and squirrels, both red and grey, also take the seeds.

CRABS AND SHRIMPS OF THE COAST

Rock pools and the lower shore along our coasts are home to some 40 species of shrimps and crabs–though not all of them are easy to find.

Above: One of the best-represented families of true crabs on our shores is the swimming crabs. This one is the wrinkled swimming crab (*Liocarcinus corrugatus*), common in some regions on the west coast of Ireland.

Below: The harbour crab (*Liocarcinus depurator*) in a rear view, clearly showing the paddle-shaped fifth pair of legs. These are characteristic of almost all swimming crabs. Also seen are the stalked eyes, with a wide field of vision.

The temperate seas around the British Isles contain fewer species of crabs or shrimps than the warm, tropical regions, where there is an astonishing diversity of these animals. Nevertheless, the visitor to the seashores of Britain and Ireland, particularly if he consults local naturalists as to the best locations and times of year, can by careful exploration eventually discover a total of some 40 different kinds of crabs and shrimps without using any more advanced equipment than a collecting net and schnorkel.

True shrimps and all crabs belong to the crustacean order Decapoda. Our shore-dwelling decapods can be classified conveniently into six basic groups: shrimps (including prawns, which are not formally distinguished from shrimps in scientific classification), mud-shrimps, squat lobsters, porcelain crabs, hermit crabs and true crabs. True lobsters and spiny lobsters are also decapods, but they are rarely found on the shore, for they normally live in sub-tidal habitats.

Shrimps in shallow water Shrimps are oval in cross section; in most species, the oval is upright in the water. But some are flattened downwards–the brown shrimp, for example. Many shrimp species have a conspicuous rostrum (beak) and well-developed swimming limbs. Mid-shore rock pools frequently contain white shrimps, whereas sandy, shallow regions often have large populations of brown shrimps, which characteristically dart around when disturbed.

Mud shrimps When sandy mudflats are exposed by unusually low tides, there is a chance of finding mud shrimps, for two of the nine species in our coastal waters occur at the lowest levels on this type of shore; the others are all inhabitants of sub-tidal mud and sand, and are therefore rarely seen. The commoner of the two shore-dwelling species is the mud borer (*Callianassa subterranea*). Its burrow openings are not easily distinguished from the holes made by burrowing tube worms, but the animal inside is a pale pinkish crustacean resembling a small lobster 4cm (1½in) long, with two very unequal claws.

Squat lobsters These animals, also called false or plated lobsters, are common beneath stones and boulders of the lower shore in some regions. They too resemble lobsters, but are even smaller than mud shrimps: *Galathea intermedia*, for example, is only 3cm (1¼in) long. When disturbed, squat lobsters move by a rapid flapping of the abdomen.

Hermit crabs Periwinkle shells in rock pools on the lower shore are the homes of juveniles of the common hermit crab. The soft spiral abdomen of this animal is hidden and protected by the shell of the dead mollusc. As the young hermit crab grows it moves into a series of increasingly larger shells, and adults often inhabit the shells of the common whelk. Large populations of the common hermit crab occur in onshore waters.

Above: The chameleon shrimp (*Hippolyte varians*), living in rock pools and shallow inshore waters, takes on the colour of its background. This one is among fronds of sea lettuce, and matches their shade of green.

Left: The brown shrimp or sand shrimp (*Crangon crangon*) is often present in large numbers on sandy and muddy bottoms and in the lower reaches of estuaries. Its flattened body shape is an adaptation for burrowing.

Below left: A common prawn (*Palaemon serratus*), found in rock pools on the English Channel coast. It is good to eat, and is fished in the Channel by local fleets using fine-meshed nets.

Below right: The pink shrimp (*Pandalus montagui*) is seen occasionally in rock pools on the lower shore and is common in inshore waters. This shrimp is also caught commercially in the Wash, south-east England, Morecambe Bay and the Solway Firth.

Porcelain crabs Another group of crab-like animals belong to the porcelain crab family, of which two kinds occur in British and Irish waters. Porcelain crabs are also called false-crabs, and look very similar to small true crabs, but have certain physical differences: the antennae, for example, are always placed outside the two eyes, not in between as in true crabs. There are also differences in the structure of the shell and the abdomen, and the larval development reveals a different ancestry from that of true crabs. Porcelain crabs live beneath the stones and rocks of the middle and lower shore.

True crabs Shore-dwelling members of this group vary considerably in shape and habitat, from the aggressive, colourful and active velvet swimming crab of the weed-covered lower shore to the tiny pea crab, which lives inside the body cavity of mussels. The pea crab is soft-shelled, but derives full protection from its host.

In a typical member of the swimming crab family, the last pair of legs is distinctly paddle-shaped; the crab uses this pair to propel itself as it swims sideways, often at high speed and usually within inches of the sea-bed. These limbs assist the other legs when they excavate soft sand, into which the crab may suddenly sink when being chased.

The shore crab is also a member of the swimming crab family, but its paddles are not developed. Shore crabs occur on nearly all types of shore, particularly from the mid-shore downwards. Adults are dull green to orange brown, but the shells of juveniles are often attractively coloured.

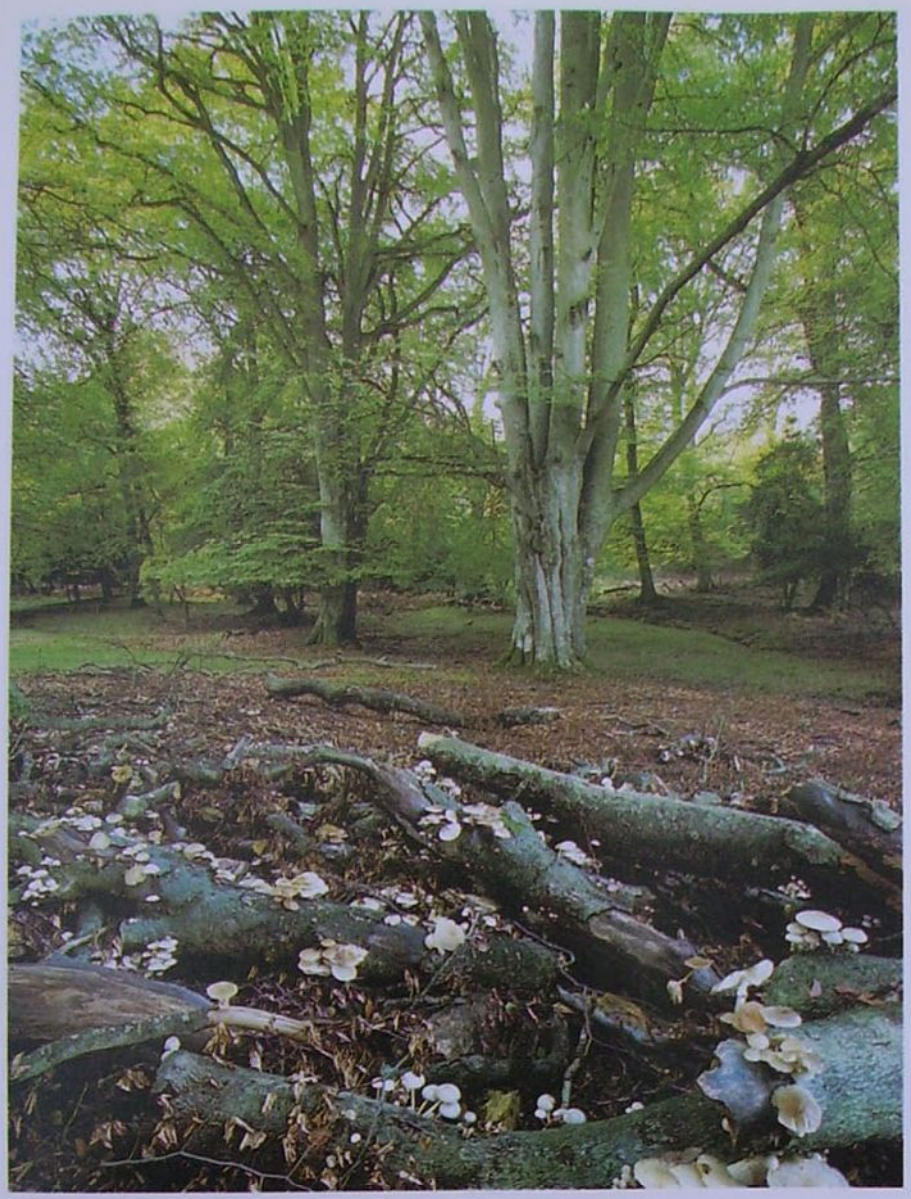
Another important group of true crabs is the spider crab family, represented by seven inshore species. The most likely one to be found at low tide among seaweeds is the long-legged spider crab (*Macropodia rostrata*); a common shallow water species found on sandy and muddy beds is the scorpion spider crab (*Inachus dorsettensis*), whose body is often encrusted with sponge and weed. A search in rock pools on the lower shore, particularly on northern coasts, may reveal the pear crab (*Hyas araneus*).

Coastal crustaceans

A classification by families of shrimps, crabs and crab-like animals inhabiting coastal waters of the British Isles

FAMILY	SPECIES	MAX BODY LENGTH	COMMON NAME
Palaemonidae	*Palaemon elegans*	**63mm**	White shrimp
	Palaemon serratus	**110mm**	Common prawn
Hippolytidae	*Hippolyte varians*	**32mm**	Chameleon shrimp
Pandalidae	*Pandalus montagui*	**160mm**	Pink shrimp
Crangonidae	*Crangon crangon*	**90mm**	Brown shrimp
Galatheidae	*Galathea squamifera*	**60mm**	Montagu's lobster
	Galathea nexa	**40mm**	Embleton's lobster
	Galathea strigosa	**90mm**	Common plated lobster
	Galathea dispersa	**45mm**	—
Porcellanidae	*Porcellana platycheles*	**12mm**	Broad-clawed porcelain crab
	Porcellana longicornis	**6mm**	Long-clawed porcelain crab
Callianassidae	*Upogebia deltaura*	**100mm**	—
	Upogebia stellata	**50mm**	Mud borer
Paguridae	*Pagurus bernhardus*	**35mm**	Common hermit
	Pagurus prideaux	**35mm**	Prideaux's hermit
Dromiidae	*Dromia personata*	**75mm**	Sponge crab
Portunidae	*Liocarcinus puber*	**65mm**	Velvet swimming crab
	Liocarcinus arcuatus	**29mm**	Arch-fronted swimming crab
	Liocarcinus corrugatus	**43mm**	Wrinkled swimming crab
	Liocarcinus depurator	**40mm**	Harbour crab
	Carcinus maenas	**60mm**	Shore crab
	Portumnus latipes	**20mm**	Sand crab
Xanthidae	*Pilumnus hirtellus*	**15mm**	Hairy crab
	Xantho pilipes	**21mm**	Lesser furrowed crab
	Xantho incisus	**22mm**	Furrowed crab
Corystidae	*Corystes cassivelaunus*	**39mm**	Helmet crab
Atelecyclidae	*Atelecyclus rotundatus*	**39mm**	Old man's face crab
Cancridae	*Cancer pagurus*	**average size 160mm**	Edible crab
Goneplacidae	*Goneplax rhomboides*	**27mm**	Angular crab
Pinnotheridae	*Pinnotheres pisum*	**(female) 13mm**	Pea crab
	Pinnotheres pinnotheres	**(female) 12mm**	Ancient pea crab
Pirimelidae	*Pirimela denticulata*	**15mm**	Toothed pirimela
Thiidae	*Thia scutellata*	**22mm**	Thumb-nail crab
Leucosiidae	*Ebalia tuberosa*	**17mm**	Pennant's nut crab
Majidae	*Macropodia rostrata*	**28mm**	Long-legged spider crab
	Macropodia tenuirostris	**32mm**	Slender beaked spider crab
	Inachus dorsettensis	**35mm**	Scorpion spider crab
	Inachus phalangium	**20mm**	Leach's spider crab
	Hyas araneus	**105mm**	Pear crab
	Maja squinado	**210mm**	Thornback spider crab
	Eurynome aspera	**19mm**	Strawberry crab

Right: The hairy crab (*Pilumnus hirtellus*) is common beneath stones on the shore, and sometimes on muddy sand. This one has found a hiding place in a small hollow in a rock. The animal belongs to a family of true crabs known as the xanthid crabs. Its body hairs retain particles of sand and detritus from its surroundings, giving it patches of camouflaging colour. The claws are either reddish brown or an attractive purple.



A FUNGAL FORAY IN SOUTH WALES

In a Forestry Commission wood in Gwent, mycologist Gerard Thomas shows us how to go about searching for fungi and identifying them in the field. Staining tests, smelling–even careful tasting of some species–all play their part.

Fungi are probably the most confusing group of plants that the amateur naturalist has to face. In Britain alone, there are at least 3000 species, with new ones being reported all the time. Yet, despite this, fungal forays (as organised searches for fungi are known) are very popular among both amateur and professional naturalists–often with an eye to finding a particularly tasty species such as a morel or a chanterelle.

Above: Poached egg fungus (*Oudemansiella mucida*) is common in beechwoods.

Right: One of the fungi easily identified with a stain test is the charcoal burner (*Russula cyanoxantha*), which is the only russula not to turn pink when stained with ferrous sulphate.

It was autumn, which is the best time of year for fungal forays. Gerard had selected Wentwood in Gwent for the foray. 'Wentwood will be ideal' he explained, 'for it has a mixture of broad-leaved trees and conifers. This will increase the range of fungi we might expect to see because quite a few are found only in association with certain broad-leaved trees, or just with conifers.

'The most important item to have is a good field guide book for helping identify the fungi. I use Roger Phillips' *Mushrooms*–both the illustrations and the descriptions of the species are excellent. We will also need a bag to collect specimens, the chemicals for carrying out staining tests and a Thermos flask of coffee–or some such strong-tasting drink. You see why later!'

The beechwood We began our search in the beechwood. It was not long before Gerard found a fungus underneath the canopy of a beech, half hidden by fallen leaves. He gently eased it out of the ground to take a closer look at it. 'In general it is best not to disturb fungi, but if you are seriously trying to identify them then you have to. You may also need to take specimens home if you cannot identify them in the field, but this should be done sparingly as well.'

With that, Gerard began to look closely at the fungi. 'It's a type of russula,' he said. 'You can tell by its brittle stem, the heavy, clearly defined gills and the fact that the colour in the cap has been partly washed out by the rain.

'Now, to find out which russula this is, we perform a few tests.' First Gerard sniffed it closely, then he broke off a very small piece of the cap and, surprisingly, chewed it to find out if it had any taste. It had no taste or smell, though he spat out the remains just to be on the safe side. 'It is safe to taste fungi–at least the fungi with gills–so long as you try only a very small piece, and spit it out afterwards. But make yourself familiar with the extremely poisonous species, such as death cap, before going out into the field. Tasting can provide an important clue–some fungi are hot, or become hot after being in the mouth for a minute or so, while others are mild or even tasteless. That's why I like to bring along a

flask of coffee, by the way–some fungi can be very hot indeed, and coffee helps to take the taste away.'

As a final clue, Gerard tried to peel the cuticle (the skin) off the cap. It came away easily. In some fungi, the cuticle only partly peels away, the bits breaking off when they reach a length of a centimetre or so. Armed with these clues, Gerard began to search through Phillips' book, but he could not be entirely certain which russula it was. 'I'll have to take this one back with me and look at it more closely.' Back at home Gerard was able to identify it as *Russula alutacea*, though he had to examine the spores under a microscope to be certain.

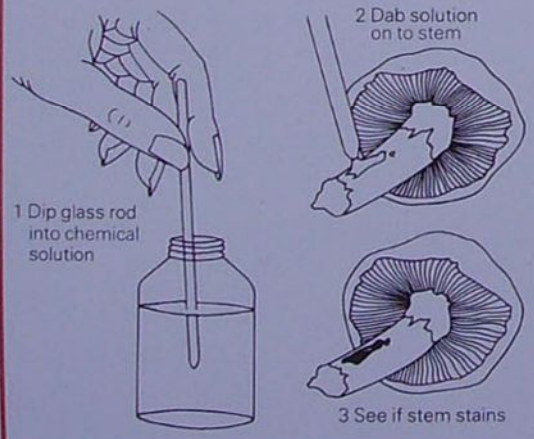
Gerard took another look around the base of the same beech tree. Looking beneath the leaf litter, he soon found two more fungi. 'These are both russulas,' he said. 'One has a bright red cap, a hot taste and a smell reminiscent of coconuts–*Russula mairei*, commonly known as beechwood sickener, and the other one we've found is *Russula ochroleuca*, the common yellow russula.' It had a yellowish cap and a mild taste.

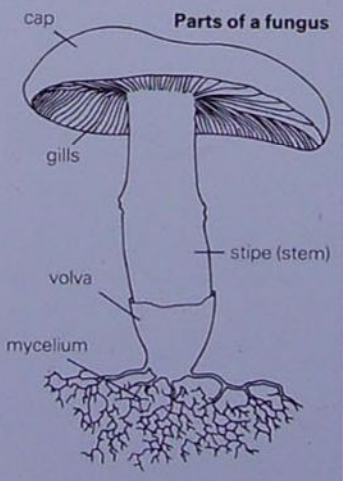
Little brown things We moved on up the side of a hill through the beechwood. 'Don't forget to look up at the trunks of trees for fungi as well as looking on the ground. Dead wood is also a good place to look. A lot of fungi are saprophytic, obtaining their nourishment by breaking down dead wood.'

Above: Earth balls (*Scleroderma citrinum*) thrive in damp soil so a good place to search for them is along the banks of drainage channels in woods.

Right: These curious-looking 'jelly babies' (*Leotia lubrica*) are not easy to spot for they grow no more than 1cm ($\frac{1}{2}$in) high. You are most likely to find them along the edges of woodland paths, and among mosses and bracken, from late summer to late autumn.

The stain test





Chemical	Species	Part of fungus	Reaction time	Result
Ferrous sulphate 20% solution	all *Russula* spp except:	stipe	1 min	deep salmon pink
	R. xerampelina	stipe	1 min	olive green
	geranium-scented russula *(R. fellea)*	stipe	1 min	cream
	charcoal burner *(R. cyanoxantha)*	stipe	1 min	no reaction
	R. erythropus	stipe	1 min	dull green
Phenol 2% solution	all *Russula* spp except:	stipe	5–10 mins	chocolate brown
	R. olivacea	stipe	5–10 mins	blackcurrant juice
Ammonia 50% solution	*R. sardonia*	stipe and gills	30–60 mins	rose pink
	ugly milk-cap *(Lactarius turpis)*	cap	30–60 mins	deep purple
Potassium hydroxide 10% solution	panther cap *(Amanita pantherina)*	cap	instant	yellow orange
	destroying angel *(Amanita virosa)*	cap	instant	chrome yellow
	Lactarius pyrogalus	milk from gills	instant	yellow orange

We soon came across a good example of a saprophytic fungus. It was a group of small brown slender fungi on a dead stump. 'This type of fungus is probably the most difficult to identify,' said Gerard, looking closely at one. 'They are known in the business as "little brown things", and furthermore these ones are old and have dried out, which makes them even more difficult to identify. I'll have take these back and work on them.' They later proved to be bonnet mycena (*Mycena galericulata*).

The next fungus to present itself was a milk-cap (*Lactarius*). This group of fungi are easily recognised by the white sap that they exude from their gills. Three important tests you can carry out on milk-caps include seeing if the milk is watery or viscous, seeing if it has any taste, and dabbing some sap on to a plain white handkerchief and waiting to observe if it changes colour after a few minutes. Gerard carried out these tests on his specimen; he found that it had a watery sap which did not turn colour on the handkerchief and had a hot taste. It also had a generally buff-coloured appearance, and Gerard deduced that it was *Lactarius insulus*, a rare species.

Puffballs and jelly Still in the beechwood Gerard noticed a drainage channel running down the side of the hill we were on. 'That'll be a good place to look,' he said, 'fungi seem to like the banks of drainage channels, partly because they like banks in any case, and partly

because of the dampness of the channel.' A quick search soon turned up some puffballs and earthballs on the ground among the leaf litter.

Further away from the channel, Gerard came across a group of tiny brown fungi with a jelly like consistency called jelly babies. They were very difficult to spot among the brown leaf litter, but they had caught Gerard's experienced eye.

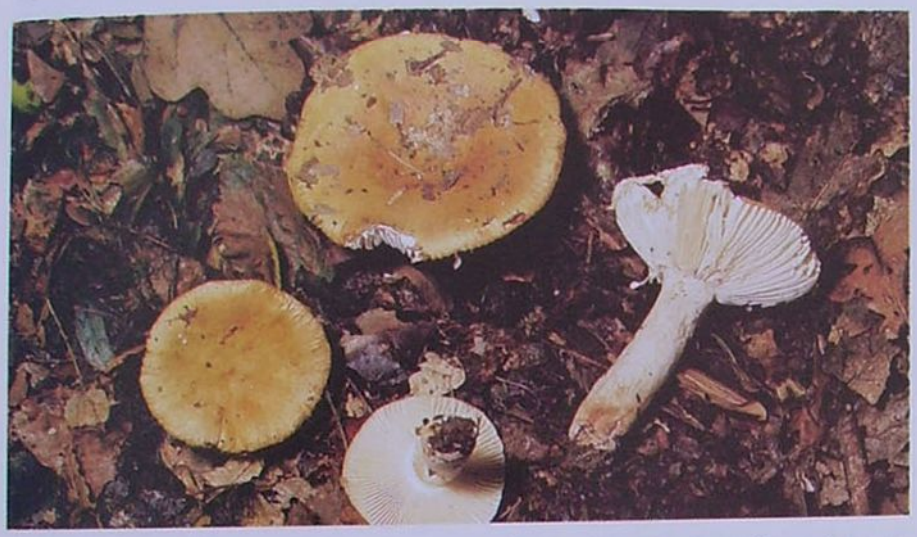
The conifer wood We walked on to a large stand of spruce planted by the Forestry Commission. Typically for a conifer wood the floor looked almost bare apart from a layer of dead needles. Nevertheless, Gerard thought we should find some interesting fungi here, species quite different from those in the beechwood.

We found a bolete within seconds. As a group they are easily recognisable by the undersurface of their caps, which have pores rather than the gills. This one was a bay bolete–its pale yellow pores turned blue when bruised, which Gerard did by pressing his finger into the undersurface.

Further on Gerard found some candle-snuff fungus (*Xylaria hypoxylon*) resembling bright slender yellow fingers, growing on a dead stump. A group of dog stinkhorns also presented themselves–small cylindrical structures about a few inches long and growing out of a small round 'egg' embedded in the soil.

The woodland path We came out of the conifer wood and back on to the path. Further along, the path became edged with steep banks about 2m (6ft) high and mostly bare soil with tree roots poking through.

We soon found several interesting species, including ugly milk cap (*Lactarius turpis*), which Gerard soon identified with the stain test, and *Clavulinopsis cinerioides*–a rare species resembling slim grey-pink fingers poking out of the bank. But the ones that interested Gerard most were a group of fungi known as horn of plenty (*Craterellus cornupiodes*). They were growing about halfway down the bank and were dark brown, almost black, in colour and horn-shaped.

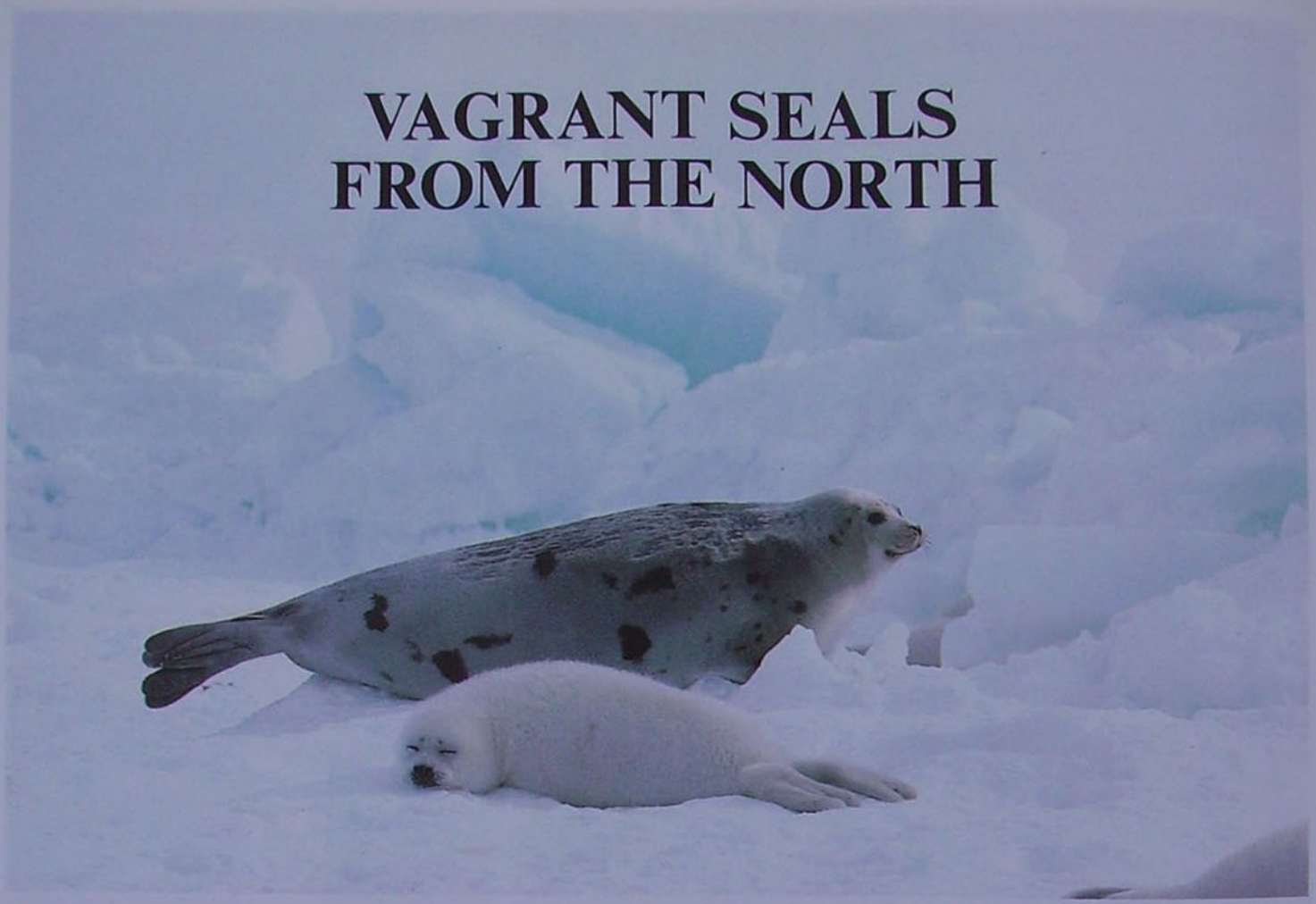


Above and top: Russulas can be very difficult to identify, for the rain often washes out the colour, making them distinctly paler than they may appear in text books. Above are two pictures of *Russula ochroleuca*: in the specimens in the top right picture the rain has had its effect on the mushroom colour, but in the left-hand picture the fungi are still yellow.

Above right: Dog stinkhorn (*Mutinus caninus*) grows among litter in woods. Its red tip is usually covered in a dark olive-green slime containing spores, so the absence of this slime implies that it has already been eaten by flies and the spores dispersed.

Right: Bay boletes (*Boletus badius*) growing among the conifers. Boletes can be recognised by the undersurface of their cap having pores rather than gills. The bay bolete has yellow pores which turn blue when you press them.

VAGRANT SEALS FROM THE NORTH



Grey and common seals are the resident breeding seals of the British Isles, but occasionally vagrant species appear from distant waters: ringed, harp, hooded and bearded seals as well as the much larger walrus have made unexpected appearances around our coast. The arrival of a vagrant is always an event.

The order Pinnipedia (seals, sea-lions and walrus) contains some 31 species which are distributed throughout the world. Around the coasts of Europe two families are represented: the true seals or Phocidae, and the walrus or Odobenidae. Grey or common seals are familiar residents in the British Isles, but ringed, harp, hooded, bearded seals and the unmistakable walrus have also been seen occasionally in British waters.

The four seals which occasionally visit British shores are perhaps less distinctive and therefore harder to identify than the walrus; but they have all travelled southwards from their Arctic habitats to reach our coasts. Ringed, harp, hooded and bearded seals breed on ice and must therefore live in the cold north where ice will be certain to form, advancing and retreating with the change of season. It is likely that as recently as 10,000 years ago, at the end of the last Ice Age, these species may have lived much nearer to the coasts of the British Isles. For example, a harp seal jaw-bone was found in the Dordogne in France, associated with an upper Paleolithic cave settlement dating back to the end of the last glacial period.

Why do they come? If the natural homes of these northern species are now so far away, why do they turn up as vagrants, albeit irregularly? Many of the vagrant seals are young individuals. Dispersal of newly weaned pups away from the breeding areas occurs in many species of seals. It seems likely that a particularly adventurous individual travels further than usual, then gets caught by the current and wind to be swept southwards out of its normal range. As far as adult vagrant seals are concerned, if there is no competition for food it may be a positive advantage for an individual to forage further afield than usual. However, so far we have no information on whether or not vagrant seals which have visited our shores have been able to find their way back to their normal range.

Ringed seal This species is about half the size of other seals. Its name comes from its distinctive coat pattern of scattered dark spots surrounded by a white ring. Individuals weigh about 60kg (130lb), although they may go up

RINGED SEAL (*Phoca hispida*)
Weight of male 60kg (130lb).
Length of male 135cm (53in).
Colour light grey background with black spots surrounded by white ring.
Breeding season 1 pup born March to April.
Gestation 270 days.
Lifespan 15-20 years.
Food crustaceans and fish.
Predators polar bears, arctic foxes, walruses, killer whales, man.
Distribution Arctic Ocean, Bering Sea, N Pacific, Baltic, Lakes Ladoga and Saimaa.

HARP SEAL (*Phoca groenlandica*)
Weight of male 135kg (300lb).
Length of male 183cm (72in).
Colour silver-grey with black head and harp-shaped band along flanks, across back.
Breeding season 1 pup born Feb to March.
Gestation 7 months.
Lifespan 30 years.
Food mainly capelin, cod.
Predators man, killer whales.
Distribution off Newfoundland, Gulf St Lawrence, Jan Mayen, White Sea.

Above: A hooded seal pup and (below right) a male hooded seal. This species gets its name from the enlargement of the nasal cavity in the males which can be inflated to form a hood or crest. The males, like this one, can blow from one nostril a curious bright red balloon shaped structure formed from the nasal septum.

Opposite page: A harp seal and pup in their normal icy habitat in Canada.

to 80kg (180lb) when in peak condition at the start of the breeding season; just under half the body weight of these tiny rotund torpedoes consists of blubber which insulates them on the icy waters where they normally feed and breed.

The ringed seal is the most numerous and successful of the northern seals. The world population may be as high as five million, but they are difficult to count because, unlike most other seals, they do not haul out on the ice surface or on land to mate and pup.

The ringed seal is unique in that it excavates a cave in the snow overlying land-fast ice. It keeps open an access hole from the water below by clawing at the ice with its fore-flippers. Both sexes excavate lairs which they use for resting, but females create additional lairs for pupping, perhaps up to three within 100m (330ft) of each other. This complex of birth caves probably provides alternative refuges to which a female can move her pup if a prowling polar bear or arctic fox threatens one lair.

Females give birth to a single pup bearing a white fluffy coat and weighing about 5kg (11lb). Pups are fed on fat-rich milk for six to seven weeks, which is one of the longest lactation periods of northern phocid seals. Towards the end of lactation females come into oestrus, and mating occurs in the water under the ice. Then, as the warmth of spring cracks and melts the ice, both young and adult seals claw through the snow to bask in the sunshine. The adults moult at this time, spending much of their days loafing on the surface, scratching at their loosening fur. The pups have already moulted in their snow lairs, exchanging a fluffy white coat for spotted adult fur. As the ice breaks up, the seals move off into open water to feed actively during the brief, northern summer. It is probably stragglers from the summer feeding forays which stray far south and occasionally land on our shores. Ringed seals could easily be confused with our native common seal, as the only identification points are the small size and coat pattern.

Harp seal This species is a member of the

HOODED SEAL (*Cystophora cristata*)
Weight male 400kg (880lb).
Length male 300cm (118in).
Colour blue-grey background with irregular dark patches, dark face.
Breeding season 1 pup born in March.
Gestation 7½ months after suspended development of 4 months.
Lifespan 20-25 years.
Food squid and fish.
Predators man, killer whales.
Distribution off Newfoundland, Jan Mayen, Davis Strait.

BEARDED SEAL (*Erignathus barbatus*)
Weight male 350kg (770lb), female slightly larger.
Length male 215cm (85in), female 225cm (88in).
Colour silver-grey to tawny or dark brown.
Breeding season 1 pup born March to April.
Gestation about 10½ months.
Lifespan 25-30 years, max. 31 years.
Food crustaceans and molluscs.
Predator man, polar bears, killer whales, large sharks.
Distribution circumpolar.

Left: Long whiskers and square foreflippers are two of the distinctive feature to look for in a bearded seal. When its abundant sensitive whiskers are wet they hang straight down on either side of the muzzle but in drying they curl up, often forming corkscrew whorls at the tips. The foreflippers look as though they have been trimmed to form a straight edge, giving rise to the Norwegian sealers' name of 'square-flipper'. Bearded seals are solitary animals, seldom found in groups. Their scattered distribution makes them difficult to census, so estimates of total numbers vary widely; the world population may be as high as half a million.

same genus (*Phoca*) as the ringed seal, but adults are easily recognised by their black head and harp-shaped black bands which run along the flanks and across the back, contrasting with the silvery fur of the rest of the body. Young harp seals might be confused with our native species because of their variable spotted coat pattern before the 'harp' forms and the animals become sexually mature. Adult harp seals are about twice the size of ringed seals and slightly bigger than common seals.

During summer harp seals are gregarious and live along the edge of the loose pack ice, migrating northwards as the edge of the ice retreats. As the ice begins to re-form and push southwards again, the seals travel ahead and eventually congregate in traditional pupping or 'whelping' areas in early spring. Newborn pups weigh about 9kg (20lb) and are covered in a coat of white silky fur. They are fed by their mothers for about ten days, growing at a rate of over 2kg (4½lb) a day–fast even by seal standards. The short suckling period is undoubtedly an adaptation to their habitat: the pack ice may break up in storms or even melt in warm springs. After lactation the females mate and then abandon their pups. The pups moult their white fur for the first adult coat, then move into the ocean to seek their own food.

Hooded seals A close neighbour of the harp seal during the breeding season is the much larger hooded seal. Hooded seals form scattered groups of solitary females with one or more males. Adults of both sexes have a strikingly marked coat of black angular patches on a silver background. The distinctive hood of the male and the red balloon are usually inflated in fighting, during sexual activity or disturbance by humans, or even when the animal is lying quietly.

Females give birth in late March to a single pup of about 15kg (33lb). Its coat is one of the most beautiful of all seal coats: silver blue-grey on the back and creamy white on the belly, and much prized by seal hunters. A white fluffy coat forms during development but is shed before birth. The suckling period is short, not more than ten days, during which time the females defend their pups fiercely against intruders.

After mating at the end of the suckling period the adults and pups disperse, apparently adopting a solitary existence. They are found further from land than harp seals, usually in deeper water in the Atlantic and Arctic Oceans. Hooded seals gather together

Above: A recently born harp seal pup stained yellow with amniotic fluid. Harp seals are probably the best known of the pinnipeds because for many years they have been the object of controversial hunts. Thousands of young seals have been taken since the late 18th century; but current estimates of 2-3 million animals mean that the harp seal is still an abundant marine mammal.

Right: Walruses are the most distinctive of the vagrant pinnipeds.

again in summer to moult, forming large groups in the Denmark Strait and off the north-east Greenland coast. After the moult they disperse to spend the winter at sea.

The coat coloration of adult hooded seals is not dissimilar to that of our native grey seal, but the larger size–up to half as much again–should make any straggler to our coasts easy to spot. The strikingly enlarged hood should certainly confirm identification of the male, as should the characteristic fur of the 'blue-black' pup.

Bearded seals These seals are solitary animals which normally live on pack ice over relatively shallow water of 30-50m (100-160ft). Apparently they cannot maintain breathing holes in thick ice, so they avoid the fast ice area which is the breeding haunt of the ringed seal. Their distribution is circumpolar, from the Arctic and north Atlantic Oceans round the coasts of northern Canada and Alaska to the northern Pacific. In summer they may haul out on beaches, but must follow the end of the pack ice as it advances and retreats with the seasons. They feed on bottom-living animals, shrimps, crabs, clams and fish.

The females give birth to a single pup from the end of March to mid-May. Pups are born on open ice floes and weigh about 35kg (77lb). They are covered in a grey-brown woolly fur, often with white patches on the head and back. This coat is moulted towards the end of the 12-18 day suckling period in exchange for the first adult coat of stiff hairs. The adults mate towards the end of lactation. During the breeding season males make a distinctive underwater sound, described as a warbling whistle, which may be a proclamation of territory. As spring turns into summer the seals migrate northwards following the re-treating ice.

Rare visitors

THE VITAL ROLE OF LEAVES

The function of a leaf is to bring together water, carbon dioxide and sunlight to produce food for the plant and then purge it of all waste products. Some leaves also provide a first line of defence for the plant against attack from the outside.

Leaves play a vital part in a plant's biology for they produce its food by a process called photosynthesis. Photosynthesis occurs in all green plants from tiny one-celled algae to the largest of trees, and in most land-dwelling plants it takes place mainly within the leaves. In simple terms photosynthesis is a chemical combination of water and carbon dioxide to form energy-containing carbohydrates (sugars). Since sunlight triggers this reaction carbohydrates are produced only during the day, although they must provide sufficient energy for plant growth, reproduction and survival through both the day and night.

Having made the carbohydrates through photosynthesis a leaf then has to convert this food into energy–a process called respiration. Respiration is the reverse of photosynthesis in that the carbohydrates are combined with oxygen to liberate energy, and water and carbon dioxide are given off as by-products. Unlike photosynthesis, respiration is not confined to the leaves but takes place in every cell in the plant, both day and night.

Layers of a leaf To discover how photosynthesis and respiration take place in such a confined space you need to look inside a leaf. If you take a beech leaf, for example, cut it in half across its width and examine the cut surface under a microscope you will see four distinct layers, each with a different cell type.

Forming the uppermost skin of the leaf is a layer of epidermal cells. These protect the leaf's inner layers from damage and bind the leaf's structure together. Beneath this upper epidermis is the palisade layer comprising elongated cells known as palisade cells. Within these cells are concentrated large numbers of small oval bodies, called chloroplasts. These contain chlorophyll, the pigment that traps the sunlight needed for photosynthesis and which is responsible for the green colour of most leaves. In sun leaves–the leaves on the upper branches of a tree–there may be two or three rows of palisade cells, but in the shade leaves, those on the lower branches, there is only one row.

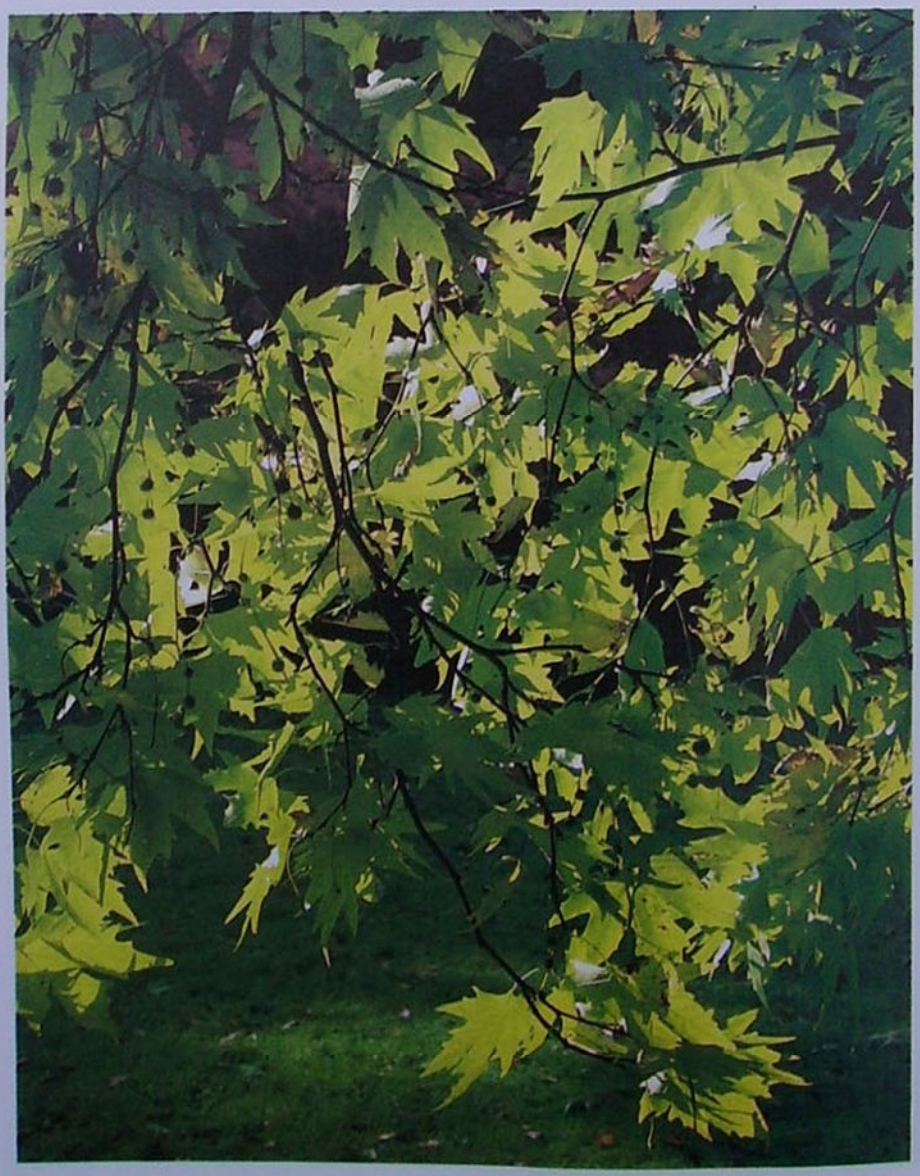
Beneath the palisade cells are some loosely packed cells which constitute a spongy layer known as the spongy mesophyll. These cells have large air spaces between them through which gases are able to pass as they diffuse in and out of the cells.

The lower surface of the leaf is bounded by an epidermal layer similar to that of the upper epidermis, except that it is perforated with large numbers of controllable valves, called stomata (stoma in the singular). These allow gases to pass between the air spaces of the spongy mesophyll and the outside atmosphere.

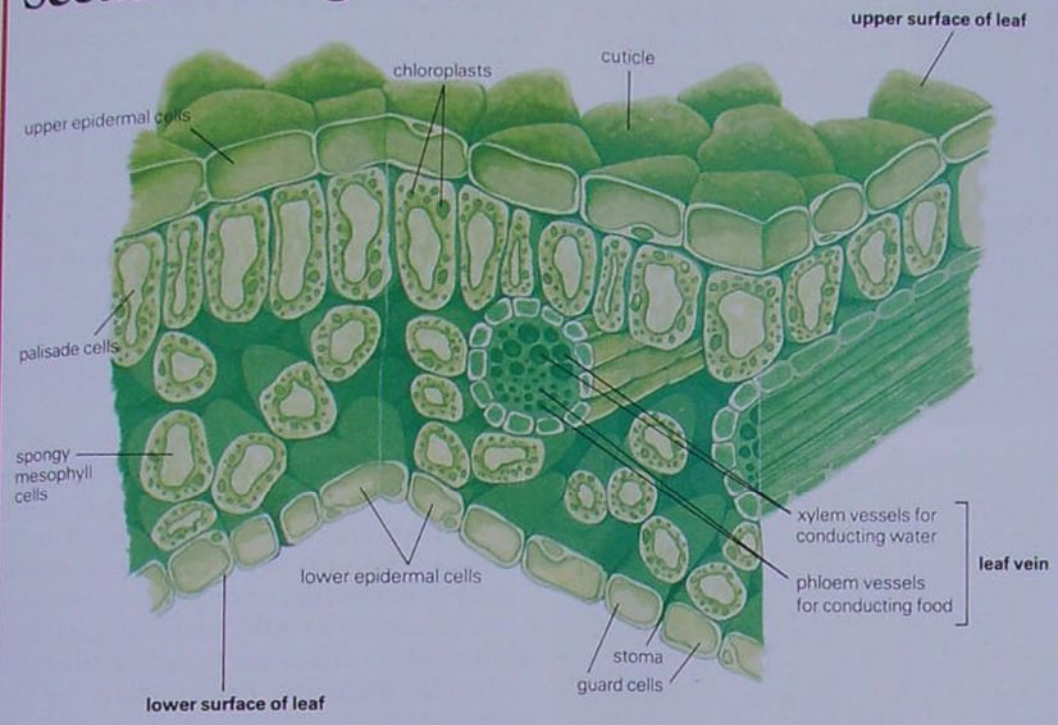
Dangers of desiccation The typical shape of a leaf maximises both the inception of light and gas exchange. Its large surface area to volume ratio could lead to rapid desiccation in all but the wettest of non-aquatic environments and so it has special structures that limit water loss.

The first of these are the stomata. One stoma is composed of two sausage-shaped guard cells. These cells become curved when full of water, leaving an aperture between them; when water is scarce they straighten to close the aperture. Thus when water is plentiful the gap between the guard cells is wide and gas exchange, at the cost of some water loss, can take place in and out of the

Below: The shapes of leaves, such as these plane leaves, are designed to facilitate the absorption of sunlight and gases. Their large surface area gives them the greatest possible exposure to the atmosphere and light, and their thinness means that gases only have to diffuse through a few cells.



Section through a leaf



A leaf consists of four distinct layers of cells, topped by a protective cuticle layer. Just beneath the cuticle are epidermal cells, which hold the leaf together and also protect the inner layers. Below them are palisade cells, inside which are chlorophyll-containing chloroplasts. The third layer is the spongy mesophyll–loosely packed cells with large air spaces between them. The final layer consists of more epidermal cells interspersed with guard cells. Between each pair of guard cells is a hole called the stoma that can open to allow gases into the leaf. Buried within the spongy mesophyll are leaf veins containing water-conducting and food-conducting vessels, called xylem and phloem respectively.

leaf. When water is scarce, however, the stomatal aperture is closed to prevent excessive, and possibly fatal, desiccation; under these circumstances little gas exchange can take place and the rate of photosynthesis is seriously reduced. But for short periods it is a small price to pay when the alternative would result in death.

Protective cuticle The stomatal mechanism for restricting water loss would be of little value were it not for another structure: covering both the upper and lower epidermal surfaces is a thin cuticle through which neither water nor gases can pass. Without a cuticle plants larger than mosses would not be able to survive in the desiccating environment on land, except under exceptional circumstances. The thickness of the cuticle varies with the type of plant. Those that grow in hot dry environments tend to have very thick cuticles, while plants in moist environments have much thinner cuticles.

Water retention is not the only function of the cuticle. Its resistant nature protects the leaf against damage and attack by disease-causing organisms such as insects and fungi. This protection is clearly not absolute, though, for some insects eat the cuticle and fungi such as rusts secrete enzymes to attack it.

The surface of many leaves is covered by yet another protective layer. On the surface of the cuticle is a complex covering composed of plates, sheets, or needles of wax. This wax layer acts as a further barrier to water, abrasion, and pest and bacterial attack.

Defensive hairs Also on the surface of leaves is a variety of hairs (called trichomes) which project from the epidermal layer. The size,

Right: In some plants the surface hairs on leaves are modified to secrete fluids. One such group of plants are the insect-feeding sundews, whose leaves are covered in long red hairs which secrete drops of sticky fluid to trap and digest prey. Because these species obtain their nutrients from insects they are able to grow in nutrient-poor soils, such as bogs, where few other plants are able to survive.

Below: The underside of a plane tree showing the midrib and veins, via which water and minerals are conducted to, and food away from, the leaves.

Left: The upper surface and (below) the lower surface of a nettle leaf. Generally the number of surface hairs is greater on a leaf's lower surface than upper surface. The reason for this appears to be that hairs prevent desiccation by trapping a layer of moist air. Since there are more stomata (breathing holes) on the lower surface than the upper it is more important for the air to be moist there–hence the presence of extra hairs.

Shapes and surfaces

Leaf shapes vary from one species to another because of the need to adapt to different environmental conditions. For example, plants in an arid climate tend to have needle-shaped leaves since they are less prone to desiccation than broad leaves. The shapes of leaf margins and the presence and shape of hairs on the leaf surface are similar evolutionary adaptations. Some of these more common shapes are shown on the opposite page, along with their technical terms. The surface hairs are shown on enlarged leaf sections, with the exception of the spines, which are on the whole leaf.

Left: Even the leaves on a single plant can differ noticeably in shape. With ivy the leaf shape varies according to whether the leaves are borne on juvenile or mature shoots. Those on young shoots are lobed (left) while those on mature shoots are roughly heart-shaped (below). The reasons for this are, as yet, unknown. Notice the waxy sheen to the ivy leaves; this is the protective cuticle layer which prevents the leaf from drying out and from being attacked by insects or fungi.

shape, complexity and number of hairs differ from species to species. Often there may be more than one type of hair present on the surface. The hairs may be a simple extension of an epidermal cell or they may be composed of many different cells. Some hairs are simple spines while others are branched. Some may resemble umbrellas (peltate hairs) or stars (stellate hairs).

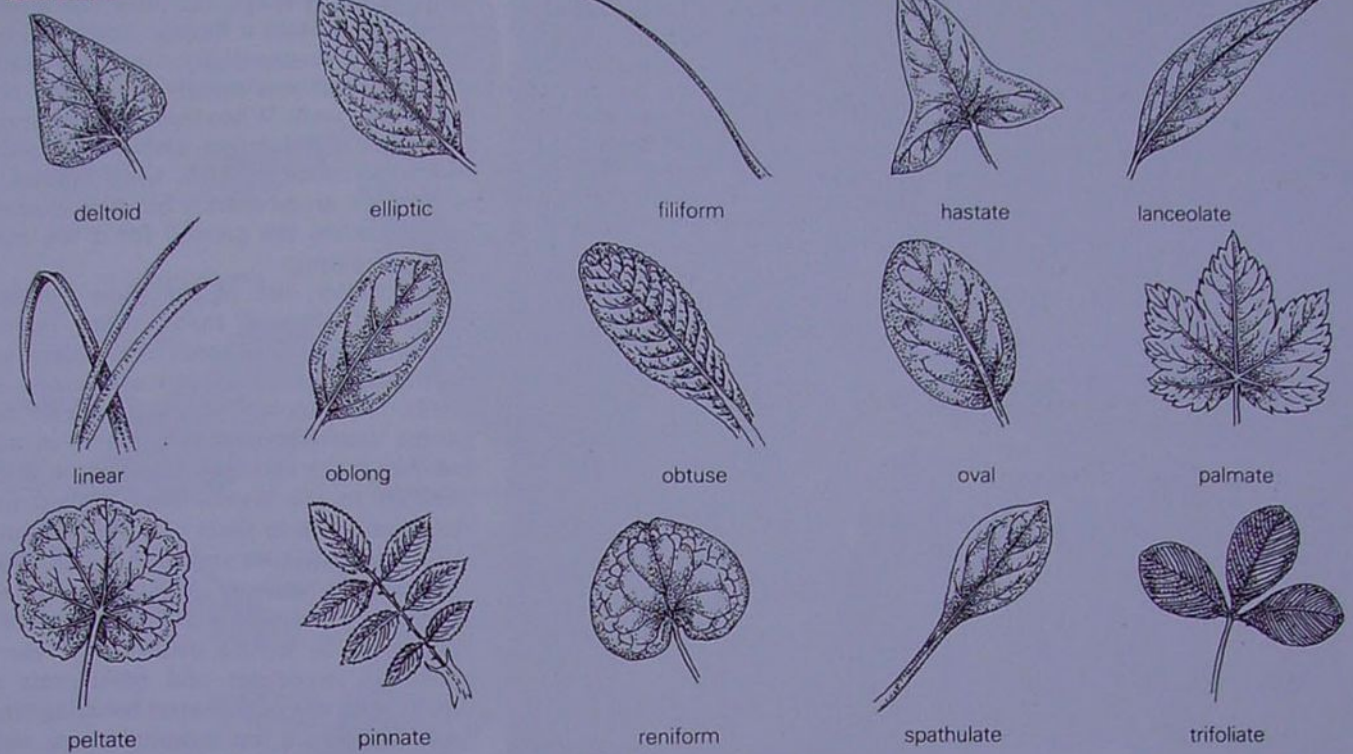
The main function of these hairs appears to be to disrupt the air flow over the leaf surface and cool the leaf. However they may also trap a layer of moist air close to the leaf surface thus helping to prevent the leaf from drying out. Another function may be to protect the leaf from the environment and deter insect pests. Plants which naturally grow at high altitudes (some species of lupin, for instance) possess extremely hairy leaves. It has been suggested that in this case the hairs may protect the plant from harmful ultraviolet radiation and from frost damage.

In many plant species the surface hairs have become modified into glandular structures that can secrete acids. A good example is the stinging nettle. The surface hairs of a nettle end in a globular tip containing formic acid–the same acid produced by some ants. If something brushes past the leaf, the tip of the hair is easily broken off and the formic acid is released: the hairs are clearly part of the nettle's defence system.

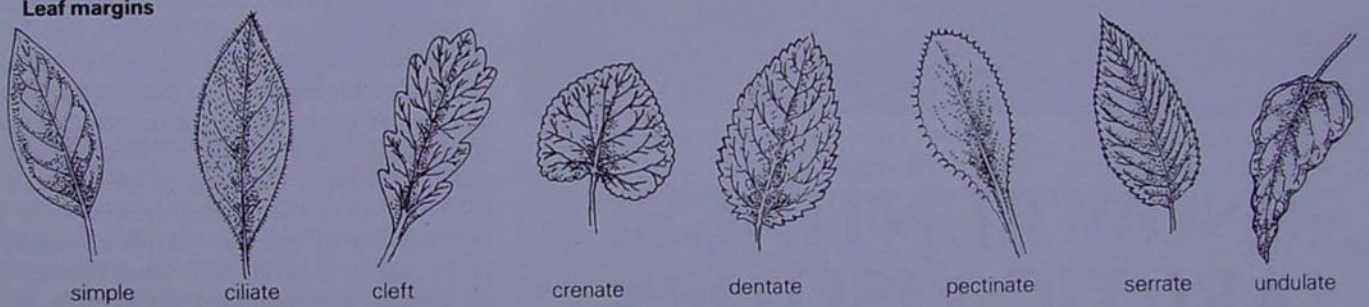
Even more specialised surface hairs and glands are found in the sundews. These insectivorous bog plants have spoon-shaped leaves covered in long red hairs; at the tip of each hair is a gland which secretes a drop of sticky liquid. Insects are attracted to the plant by the glistening hairs and become trapped by this sticky fluid. As the insect struggles the hairs bend and attach the insects even more firmly to the leaf surface. The leaf then secretes digestive juices to break down the insect's body tissues. These juices, containing nutrients for the plant, are then absorbed back into the leaf. The whole process takes several days; once all the juices have been absorbed the leaf uncurls and the dry husk of the insect is blown away in the wind. The leaf then waits for its next victim.

Leaf terms explained

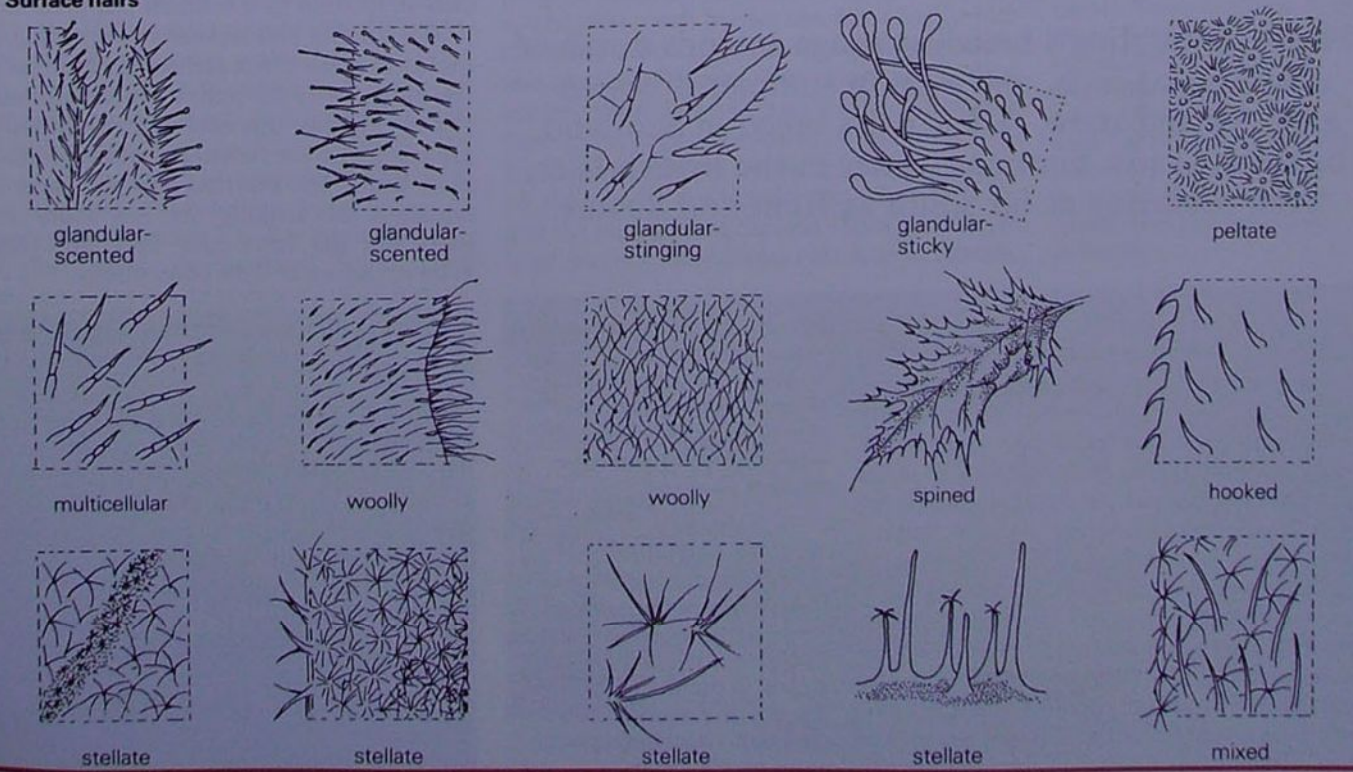
Leaf shapes

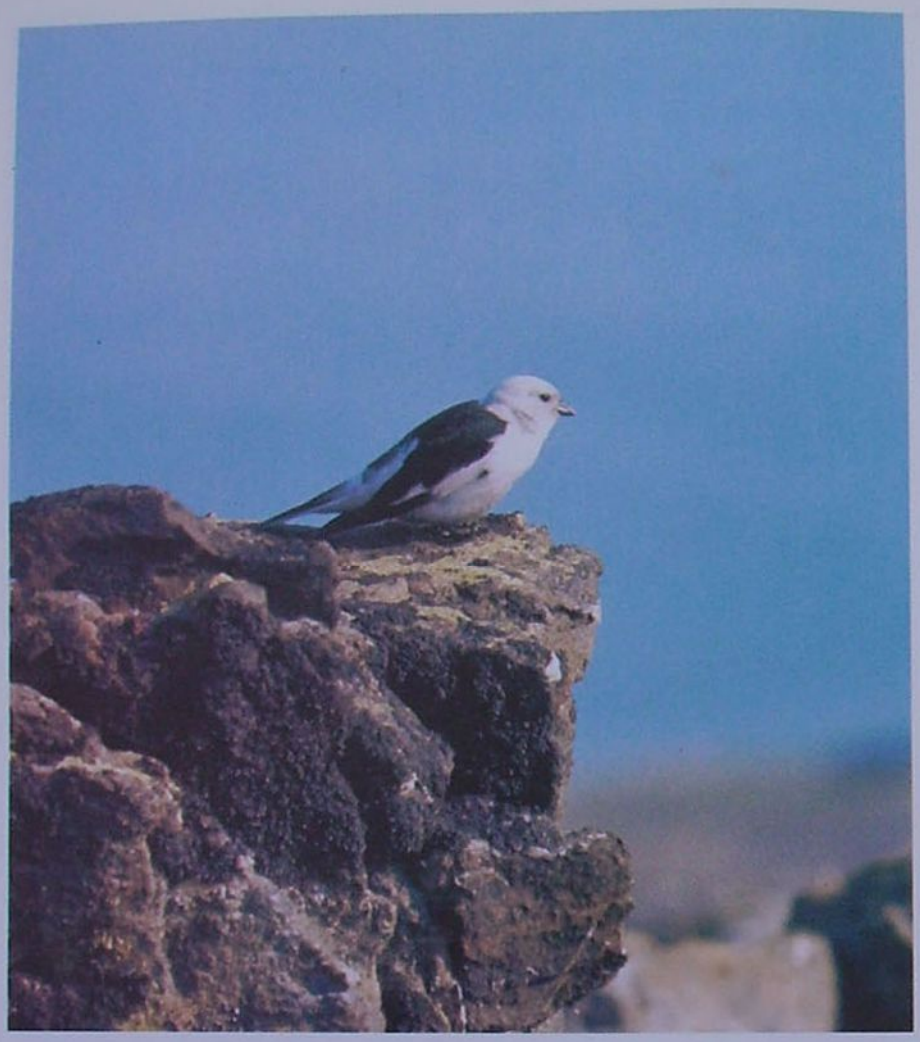


Leaf margins



Surface hairs





SNOW BUNTINGS: ARCTIC VISITORS

The snow bunting's breeding range extends north of the Arctic Circle, and even in summer it is seen amid ice and snow. A few pairs breed in Scotland, but many snow buntings winter in the British Isles, even occurring as far south as Kent and Sussex.

The majority of British birdwatchers encounter the snow bunting as a winter visitor, mainly between October and March, on coasts and on inland hills. It is highly gregarious, and can occur in spectacular flocks, containing 500 birds or more. It often associates on coastal flats with a variety of other finches and buntings such as linnets, twites, corn buntings, and the much rarer Lapland buntings, as well as skylarks, meadow pipits and sometimes shore larks. Such massed flocks are naturally attractive to predators, and it is thought that merlins and sparrowhawks actually single out snow buntings from mixed flocks, possibly on account of their conspicuous black-and-white plumage.

Above: A male snow bunting in summer, proclaiming his territory. The song is a loud, fluting trill, and birds are therefore easily located, by both their song and their brilliant plumage.

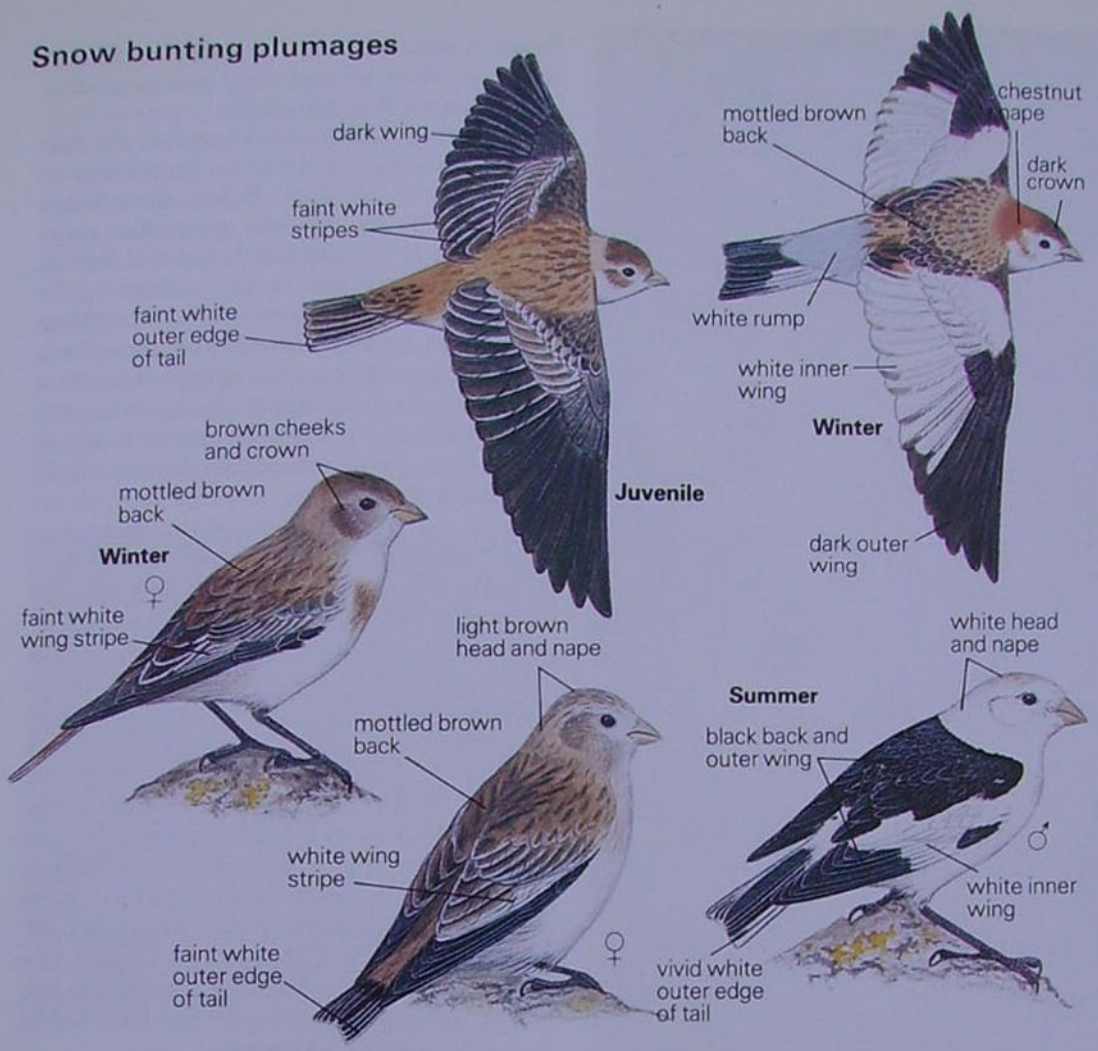
Right: A male snow bunting in winter, photographed in grass close to the coast of southern England. It is rare for a snow bunting to occur inland in the south, while in the south-west it is seen only as a bad-weather migrant, even on the coast.

Buntings on the beach The first indication of the presence of snow buntings on a desolate winter beach is one of its calls, a far carrying 'teu'. At closer range, the flock can often be heard to maintain a fluting, musical twitter. The species is essentially a ground-dwelling one: the birds run rapidly across the beach rather than walk. When they leave the ground, their flight is undulating, and both individuals and flocks often fly high; when landing, the entire flock drops quickly but then characteristically skims the ground for a few metres before alighting.

The winter diet of the snow bunting is typical of that of many other buntings, consisting mainly of seeds of various grasses, plantains, docks, samphire and many other plants. The snow bunting also eats cereal grains, sand-hoppers and insects in winter but, like many shorebirds, its diet in summer switches to the insects that abound in the Arctic and also in parts of Scotland–notably midges, mosquitoes and their larvae.

Scarce in summer Watching the snow buntings in summer is a different experience altogether. In British ornithology, the bird holds an important and prestigious position, for it is one of the rarest breeding birds. It is restricted to a few mountain tops, usually over 1000m (3000ft), Scotland being its southern-most breeding area in Europe. We do not know how many pairs breed each year, for no systematic bird census has been carried out in the remote peaks of the Cairngorms. It seems likely that the breeding population can, at most, number a few tens of pairs, but even then studies in the Cairngorms indicate that the number of breeders varies considerably from year to year. In poor years females may be absent, and unmated males may be the only indication of a resident population.

The scarcity and isolation of breeding birds means that few birdwatchers are familiar with the full glory of the male's breeding plumage. His back, wing tips and central tail feathers are black and the remainder of his plumage is pure white. His bill and legs are black. The female is less striking: she has white underparts but her head and back are greyish-brown, the latter with black flecks.



Above: The summer range of our resident population of snow buntings, breeding in Scotland. The range of the wintering birds has not yet been charted with the same precision, but they are regularly seen in every county of Scotland. In England their range is mainly on the east coast, extending inland only to the Pennines and Northumberland Moors. They also occur on the south coast, while small numbers visit the Kent and Sussex Downs.

Snow bunting (*Plectrophenax nivalis*). Small resident population restricted to mountains of northern Scotland. Larger wintering population. 16.5cm (6½in).

Both sexes become duller after the autumn moult. The underparts of the female become dirty white, and the male develops chestnut markings on the head while his back becomes mottled brown. He retains the brilliant white patches on his wings, however, and these can give the impression of snowflakes against a cloudy sky. Before winter migrants depart in March and April, some males may begin to attain their breeding plumage by losing the brown head markings and developing a black back and a black, rather than yellowish bill: this is the best chance that most of us have of seeing this beautiful breeding dress.

Display and breeding The few snow bunting pairs that breed in Scotland begin their nesting activities late in comparison with most of our more familiar birds, for eggs are not laid until late May or early June.

The male establishes a large territory, often of several hectares, advertising his presence by a song flight, in which he rises about 10m (30ft) with fluttering wings and spread tail, amply displaying the contrasting black and white of his plumage. He then glides down with his wings held in a 'V' shape, a position that is held when the bird lands. Snow buntings also sing from prominent perches such as rocks, and where the birds are abundant in the Arctic, some visitors to these regions have noted that each large boulder has its attendant singing male.

Males generally arrive first in the breeding areas, and later attempt to attract females to their territories. In his courtship display, the male walks slowly away from his mate, spreading his wings and tail to display his black and white patterning. When he is about 2m (6ft) away, he closes his wings and runs back to the female's side.

The nest, built by the hen but usually with the male nearby, is constructed of grasses, mosses and lichens but lined with finer materials such as hair and feathers. Between four and six eggs, occasionally more, are laid. Incubation, mainly by the female who is fed on the nest by her mate, takes 12 to 13 days, and the young leave the nest about a fortnight later. Females sometimes rear second broods.

Below: Snow buntings in the snow. Despite the small size of the Scottish breeding population, flocks like this are seen in spring after a fresh fall of snow. The birds temporarily abandon their territories and congregate where food is most easily available.

THE MYSTERY OF INSECT SWARMS

Swarming behaviour is seen in many kinds of insects in the British Isles. It can be destructive, as in the local plagues of crop-eating thrips, or terrifying, as in the swarms of honey bees–which are harmless as long as they are handled correctly.

A great many different insects swarm, and they do so for a wide variety of reasons. Some, such as honey bees and ants, swarm to help found new colonies; others, such as ladybirds or aphids, gather together as a means of gaining mutual protection. Huge swarms of flies, thrips or beetles can appear occasionally when their numbers increase rapidly and they fly off in search of new food supplies. This is the time when we are most aware of tiny insects normally overlooked.

Breakaway bees In the honey bee the first swarm of the year follows the production of new queens in the hive. Before these hatch from their pupae, the old queen flies away with a swarm, leaving her home and half or more of its population of workers to be maintained by whichever of her daughters manages to establish herself over the others. The old queen gathers her swarm of workers around her on some support such as a branch. Scouts then fly out from the swarm in search of a hollow tree or some other suitable site to establish a new colony.

From the point of view of the beekeeper, once the swarm has gathered on a branch he can shake it off and collect it in a suitable receptacle. The swarm can then be put into a hive where the bees settle down and form a new colony. The earlier in the season this is done the better, for a hive established early has a longer time to produce honey. 'A swarm in May is worth a load of hay' is an old country saying that reflects the value of bee colonies founded early in the year.

Among social bees and wasps, swarming is associated only with those species whose colonies survive through the winter. In the British Isles only honey bees fall into this category; bumble bees and wasps do not swarm as their new colonies are founded in spring by hibernated queens.

The purpose of spring swarms is reproduction of the colony. Swarms of honey bees that appear later in the year serve a different function. These are called mating swarms and result from workers following queens out on their mating flight. The misled workers may seek new homes or return to their original

Above: A swarm of bees, with up to 30,000 workers and a single queen, clustering round a branch.

Right: Many gardeners have suffered from swarms of bean aphids on their crops.

colony.

Winged ants The nests or colonies of ants are also reproduced by a sort of swarming, but this has a very different pattern from that of honey bees. One of our most abundant ants is the black garden ant which is seen swarming every summer. In this species the emergence of winged adults is simultaneous over a wide area of the country. The emerging winged males and females, or queens, are tended by the frantic workers before flying upwards in the early evening. They usually make for a conspicuous object in the landscape and gather in large numbers around it. If high above the ground the swarm may look like smoke, and there are records of the fire engine being called out in response to an alarm call caused by thousands of flying ants swirling around a church steeple.

For ants the swarming is really a 'marriage' flight in which males and females, often from different colonies, meet and mate in mid-air. The queens then descend to the ground and deliberately break off their wings. Some may enter existing nests, but most of them seek out crevices in which to shelter and lay eggs for the foundation of new colonies. Needless to say only a minute proportion of the swarming queens achieve success; birds and other predators take a heavy toll of the ants both in the air and on the ground.

Food for fish On warm, still days in summer, adult mayflies emerge at the water surface. After having lived for two or three years in the water as aquatic larvae, they fly briefly as dull coloured immature adults before finally shedding their skin to reveal the true adult. The males then perform a mating dance over the water, the occurrence of which is an encouraging sight to trout fishermen as the fish are stimulated to feed by the emerging swarms of mayflies. The movement of numerous males in the swarm attracts females, and mating takes place in the air. The adult life of mayflies is very brief, lasting from one to four days.

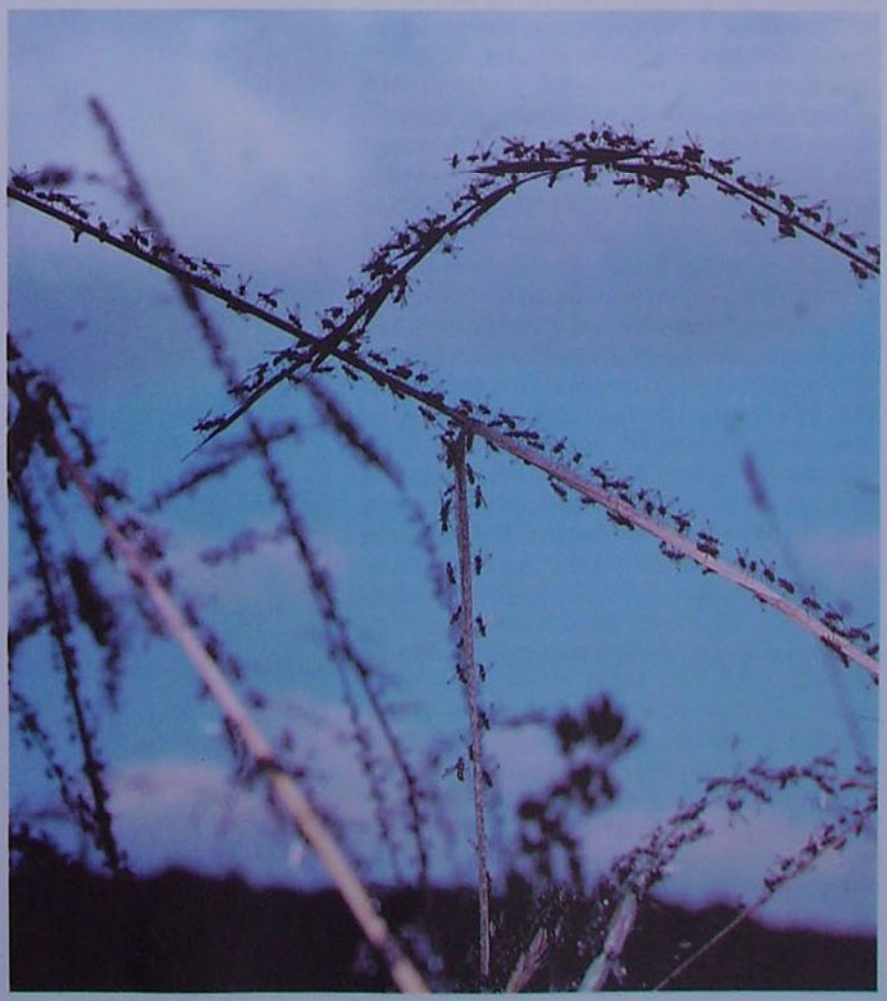
Mating midges Similar behaviour occurs widely among the true flies or Diptera. On warm evenings small swarms of non-biting

Myriads of bugs

Every few years abundant food and suitable weather conditions enable some insects to undergo a population explosion. In the summer of 1983 sallows became infested with tree hopper nymphs. These feed on sap, and in normal circumstances hide within white frothy 'cuckoo-spit'. However, when numbers are high the froth turns to water and drips from the trees.

Left: At the start of winter 7-spot ladybirds hibernate in swarms under logs or in vegetation. There they produce an evil-smelling chemical to deter birds and other predators from attacking them in this vulnerable state.

Below: A memorable sight in late summer hedgerows and woods is the mating swarms of sepsid flies. These small black flies gather on leaves or dead stems and engage in characteristic wing waving.



midges (*Chironomus* species) can often be seen rising and falling in the air with a characteristic motion, yet remaining above the same place despite the light breeze and eddies of air that are always blowing. They keep in position by visual reference to some conspicuous object such as a tree or post. The coherence of the swarm and its up and down motion form a rallying point for males to gather and also signals to females, which fly into the swarm to be mated.

Similar swarms can sometimes be seen on sunny days in winter. These also consist of flies, but belong to the genus *Trichocera* which are relatives of the craneflies. They are appropriately known as winter gnats, and swarms of males gather and dance up and down to attract yet more males and females.

Thrips and flies On hot summer days the tiny black insects called thrips or thunder flies may appear in vast numbers without exhibiting any particular swarming pattern or behaviour. Each one is only about 2mm long yet collectively they can be a great nuisance if they appear in large numbers and swarm over your skin. They are particularly common around cereal fields where the adults and larvae feed upon the crop. In such country areas they appear in huge numbers on hot summer days and crawl into every conceivable crevice.

Some kinds of flies hibernate in large numbers together, and may cause alarm by congregating in upper rooms or attics of houses. There is a tendency for the same places to be used year after year, possibly because outdoor air currents carry the flies there, or because the sites have some quality suitable for hibernation. The cluster fly, *Pollenia rudis*, is one of the most frequent invaders, and is a little larger than the common house fly but with brass coloured hairs on its thorax. Another swarming fly is the small black and yellow *Thaumatomyia notata*. This may appear in large numbers when warm autumn weather causes premature hatching of pupae which normally overwinter.

Some kinds of flies, especially those of the genus *Coelopa*, breed in stranded seaweed on the shore. These sometimes upset holiday makers by appearing in huge numbers above the sand, all moving in one direction. They are attracted to various aromatic substances such as sun-tan oil and perfume and may be a nuisance, albeit a harmless one, in sea-front chemist shops.

Flies and man Some swarms of flies owe their existence to human activities. The filters of large sewage works attract many insects normally found in mud and sludge. Among these are the tiny moth flies (*Psychoda* species) and non-biting midges. The inevitable rubbish dumps which are formed near towns and cities can be ideal breeding grounds for a whole host of flies, some of which may carry disease.

Above: Many insects swarm to bring together the sexes for mating. An example is the longhorn moth, *Adela reaumurella*, which collect on bushes in spring.

Right: Greenfly gain some protection by swarming on plants. There they secrete a sweet substance to attract ants, the presence of which deters the greenfly's predators, birds.

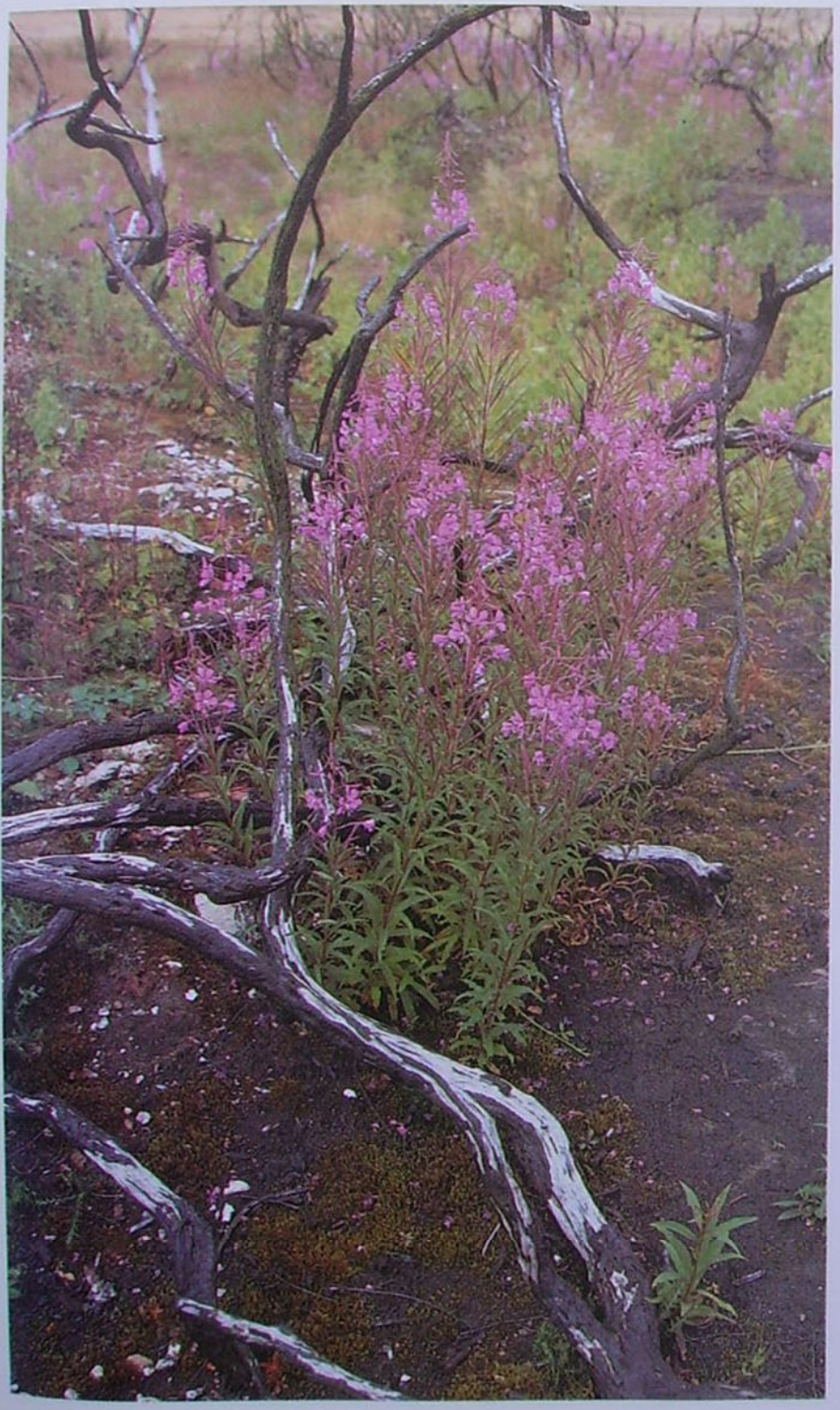
Below: Winged males and queens of the black garden ant swarm in summer.

HEATHLAND FIRES

One of the most destructive forces in nature – fire – plays an essential role in the ecology of heathlands, clearing the ground to allow the cycle of colonization to begin anew.

Right: Many of the earliest plants to appear after a heathland fire are those that can store food in their roots. Such plants, like this tormentil, can quickly produce new growth and start to colonize the bare ground.

Below: Burnt heathland lying close to farmland is likely to be quickly colonized by rose-bay willow-herb, whose light airborne seeds drift in and soon become established.



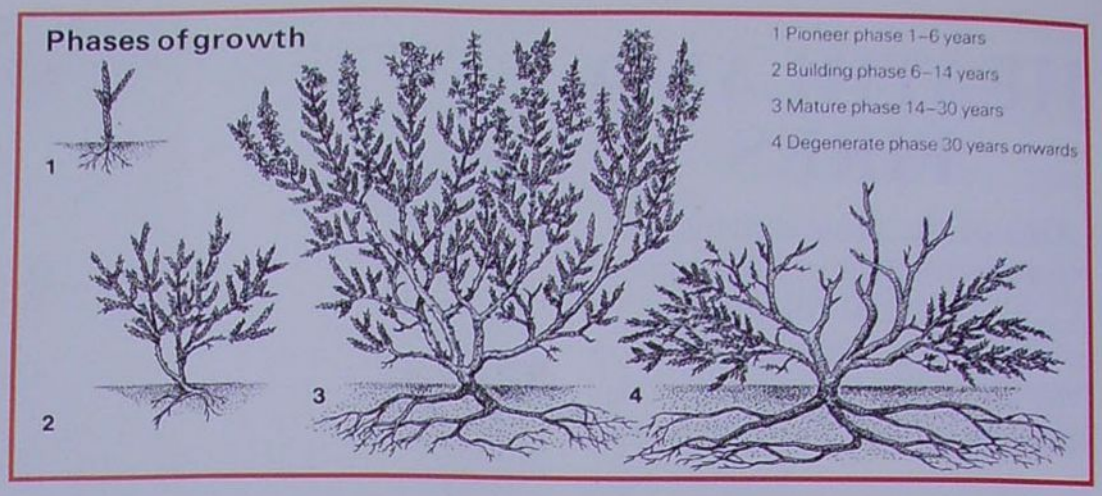
Heathland and its upland counterpart, moorland, are the only habitats in the British Isles in which fire plays an important role. These open areas of dwarf shrubs were mostly created by man when he cleared the natural woodland to establish grazing areas for his animals. The grazing prevented the woodland from regenerating and, without the cover of trees, nutrients were slowly washed out of the soil, which became poorer and more acidic. The conditions thus became suitable for the growth of heathland plants.

Throughout their history heathlands have been periodically burned by man to encourage the growth of nutritious grasses and young heather shoots for his animals to feed upon. Regular burning still occurs but it is now controlled by law and confined to the winter months. The grouse and sheep moors of northern England and Scotland are burned on a cycle of ten to twelve years. In lowland Britain there are few heaths that are now used for grazing, so controlled burning is more or less a thing of the past. Nevertheless these areas are frequently and haphazardly burned by the public carelessly throwing away lighted cigarettes or matches, or lighting picnic fires – sometimes the fires are started deliberately by arsonists.

During the fire Fires sweeping through heathland vary in their intensity and effect. A light fire will run through the canopy of the plants only, leaving the woody stems and

Right: Heather plants slowly regrow after a fire, passing through four distinct phases as they do so. Most are killed by the next fire before they reach the degenerate phase when they die from the centre.

Below: The fire and after. Top, New Forest heathland ablaze; middle, the immediate aftermath of a fire at Hindhead in Surrey; bottom, regeneration four years after the fire at Thursley Heath in Surrey.



ground litter unburned. A more intense fire will burn all the vegetation but leave the roots and animals in the soil unharmed–this is the type of fire that farmers and gamekeepers aim at since it ensures a good regeneration of the heather. In the most severe fire all the vegetation above and on the ground are burned, as are the upper layers of the soil, resulting in the death of heather roots, seeds and sheltering animals.

The temperature reached during a heathland fire varies greatly: in a moderate fire it may be from 200°C to 400°C, but could reach twice this in a severe fire, depending on the age of the heather and therefore the amount of vegetation that has grown since the last fire. On the soil surface the temperature may be much less, perhaps no more than 200°C, while in the soil itself the temperature can be a great deal less because of the insulating properties of the ground litter. A few millimetres into the soil the temperature may not exceed 65°C and at the depths below 1cm (½in) there is hardly any change in temperature, even during the most severe fire.

After the fire The open burnt ground is the starting point for a succession of colonizations by plants and animals that will cover a period of up to 40 years. After that, if the heathland has not caught fire again, it will slowly turn into woodland–of birch and, later, oak.

One of the first effects of the fire is often to stimulate the appearance of fungi such as *Humaria* and *Rhizina*. Both live in the soil as long thin strands called hyphae. If the hyphae ar far enough down into the soil they will be unaffected by the heat and, once the fire is over, send up cup-shaped fruiting bodies on to the soil surface. The burnt ground may also be quickly colonized by a reddish-brown mat of the alga, *Zygogonium ericetorum*, and lichens soon follow, mainly species of *Cladonia*, a group of mostly lobed, greyish-green lichens. Mosses also grow on this open ground, the most common being *Polytrichum poliferum*, *P. juniperinum* and species of *Cephaloziella*.

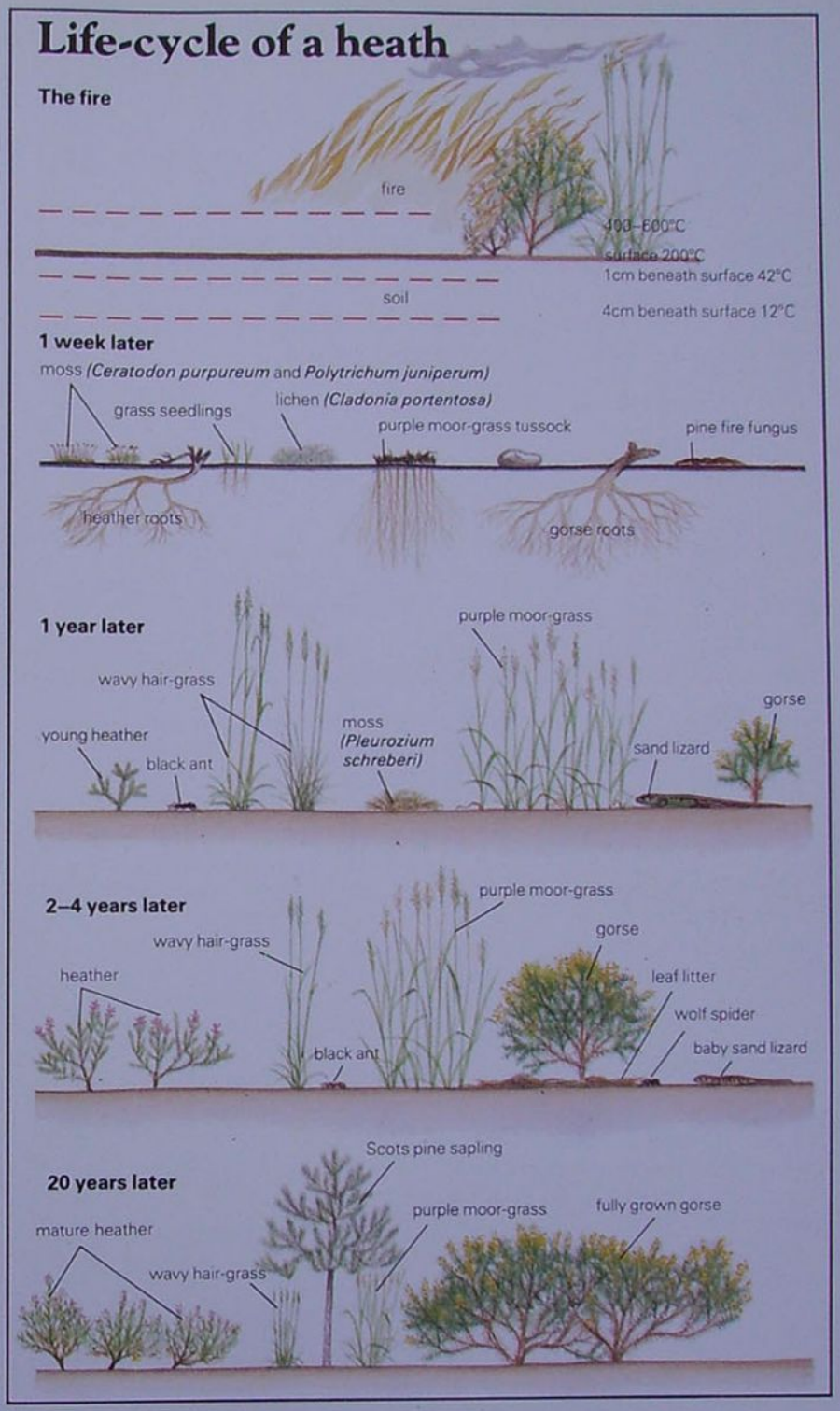
The first flowering plants to appear after the fire are grasses. Purple moor-grass soon springs up because its roots are able to store food out of reach of the fire and so the plant

can quickly grow new leaves. The open ground is ideal for the establishment of other heathland grasses from seed, particularly bristle bent in southern England and wavy hair-grass in many other areas. The conditions after a fire provide about the only chance these grasses have of becoming established.

Regrowth of heather If the fire has been only moderate the roots of the heather plants will not have been killed and in the first season afterwards they sprout succulent shoots. On the other hand, if the fire has been severe then the heather can regenerate itself only from seeds buried in the ground. Assuming that the seeds survive the heat of the fire in the first place they actually benefit from a certain increase in the temperature, for they germinate more readily if exposed to temperatures up to 40°C. Furthermore, the fire improves the quality of the soil by burning the loose vegetation on the ground, enabling the heather seeds to root themselves more easily into the soil. The seeds are also helped towards germination by the increased amount of light reaching the soil surface once the vegetation has been burned away.

Between one heathland fire and the next, heather goes through four clearly marked phases. The first six years are the pioneer phase, when the plants grow from seedlings to small pyramidal bushes. The next seven or eight years are the building phase, during which the plants become more branched and woody–in this period the canopy of the bushes closes over at a height of about 30cm (12in) to 40cm (16in). After this comes the mature phase, which lasts until the heather plants are about 25 years old and have become fully grown. Towards the end of this phase the canopy begins to open. Finally, once the plants pass the age of 30 years they enter the final, degenerate, phase when the branches fall outwards, exposing the centre of the plants. The green foliage decreases and the plants gradually grow old and die.

As the old plants die the spaces they leave behind are colonized by seedlings, though this rarely happens in practice since most heathlands catch fire before they reach this stage–patches of heather more than 20 years old are



Above: Between one fire and the next a heath is colonized by a succession of different plants and animals, some adapted to the open conditions of a young heath, others to the dense vegetation of an old heath. Few heathlands survive more than 20 years before being burned, whether accidentally by the public or in a controlled manner as part of a conservation programme.

Left: Bracken regenerating just two weeks after being burned in a heathland fire.

hard to find. The capacity of the roots to produce new shoots after a fire decreases as the plants grow older– heathland needs to be burned at intervals of not more than 20 years if the rootstocks are to be kept perennially young and capable of producing new shoots.

Succession of animals Just as there is a succession of plants over the years following a heathland fire, so there is a similar succession of animals in response to the changing vegetation. Many small insects are likely to survive the fire, especially if they are able to shelter in the upper layers of the litter. But after the fire, with their food supply destroyed, these insects will die, and without shelter they are easily caught by predators. These species will be temporarily absent from the heathland, their place being taken by species that prefer open conditions.

Of the three species of ant that live on southern heathlands the turf ant is present at all stages of the succession, though it becomes more abundant in the later phases. In contrast, the other two species, which are both black ants, need warmer soil and so are commonest in the early stages before the canopy closes.

Spiders show a similar pattern of succession. The pioneer species live on the ground, spreading over the burnt heathland by running over the ground or sailing through the air on threads of web. These species are then replaced by others that prefer the moist conditions under a closed canopy. In the later stages of the succession web-spinning spiders predominate; they take advantage of the branched plants where they can hang webs.

Lizards are best suited to the final degenerate phase of a heathland, when there is a rich supply of insects as food and the plants have begun to die away at the centre. The sand lizard, however, may often be found on the open ground of the pioneer phase. This species of lizard, which is one of our rarest reptiles, is becoming endangered by heathland fires (among other factors). The problem is that, since our heathlands have decreased and some split up from each other, it is very difficult for sand lizards in one stretch of heathland to colonize another, separate, stretch after a fire.

Careful burning Because of the problem of colonization, for the sand lizard and other animals, great care has been taken when using fire as a tool for nature conservation on the few heathlands left in Britain. On a large heathland a small piece can be burned every year and colonization will then come from within that heathland, but if smaller areas are entirely burned colonists must come from outside.

For this reason, some people advocate cutting the heather and scrub as an alternative to burning, yet this would not reproduce the conditions provided by the fire–conditions that much of the heathland community needs if it is to survive. Where it can be safely and wisely used, fire is the most effective way of managing heathland.

People's memories are short: the fine heathland on Hartland Moor in Dorset, which was burned in the dry summer of 1976 and the loss of which was so mourned, had in fact grown up since a similar fire in 1959. In time it will grow again.

Above: The rare marsh gentian benefits from a fire since it flowers more profusely afterwards.

Below: Purple moor-grass is a common heathland plant, quickly regenerating itself after a fire.

OBSERVING NEWT BEHAVIOUR

In spring you can easily observe newts in ponds or canals, and it is rewarding to watch them at night, using a torch. In summer and autumn they are harder to find for they live on dry land and hide under logs and stones, where they will later hibernate.

Anyone who devotes a few outings to visiting ponds with net and bucket between March and June will learn much at first hand about the activities of newts. The pond hunter may even come across a very rare animal, the great crested newt (*Triturus cristatus*), also known simply as the crested newt or the warty newt. It is wise to prepare in advance for this eventuality by looking at illustrations and perhaps taking along a field guide that shows the appearance of this animal. (It is also recognisable by its size, growing to 15cm (6in) compared with the 10cm (4in) of the smooth newt, the next largest.) If you identify a great crested newt, it is as well to know how you stand in the law, for the newt is listed in the Wildlife and Countryside Act as one of our most strictly protected species. This means that anyone who intentionally kills, injures, takes or handles a great crested newt without a government licence is committing an offence.

The Act does not, however, forbid anyone to watch the great crested newt, and amateur naturalists are fully entitled to spend time at the site, provided they are not disturbing the habitat or trespassing. It might prove helpful afterwards to inform the county naturalists' trust, and indeed this is a good place for anyone to apply for more details about the Wildlife and Countryside Act.

The commoner newts of the British Isles–

Above: Netting a newt in a garden pond. Used with care, a small pond net or dip net is very suitable for lifting the animals from the water, but it is important not to disturb the pond too much. Once caught, the newt should be handled as little as possible.

Right: Young newts (this one is a smooth newt) look noticeably 'big-headed' until the body grows to full size. Smooth newts grow to 10cm (4in) long.

Above: Two scenes in the newts' courtship dance (both pictures show aquarium specimens of the great crested newt). On the left, a male is displaying his vivid crest to the female. On the right, a male reveals his orange-yellow belly: each great crested newt has its own individual belly pattern.

the palmate newt (*Triturus helvetica*) and the smooth or common newt (*T. vulgaris*) are also mentioned in the Act, but theirs is a lesser degree of protection. It is not an offence to collect them, and if you have a freshwater aquarium it is very interesting to keep them for a few days before returning them to the wild. The law simply forbids anyone to sell or advertise the sale of these newts without a licence.

Where to look Sites inhabited by the smooth newt are fairly common: they are widespread throughout the British Isles, though they are most abundant in south-east England. The animal may be found in many ponds, lakes and waterways, but is more abundant in ponds with a rich array of aquatic vegetation and a surrounding area of scrub or low-growing trees.

Palmate newt sites are widely scattered throughout Britain (but not Ireland). In recent years this newt, too, has declined in numbers. It can tolerate a wider variety of conditions than the smooth newt: from the coast to uplands, populations can be found in temporary ponds, Scottish tarns, heathland and moorland ponds and stagnant pools, as well as the kinds of habitats in which smooth newts can live.

Great crested newt sites are scattered throughout central and south-east England; there are some in Wales and a very few in Scotland. The natural habitat of this newt is a lowland pond with fairly deep water and an area of scrub nearby.

Garden ponds, provided they are not too small, can provide good habitats for newts of all three species, and newts may colonize a new pond within a year or two of its being built. It is important that the pond should be at least partly surrounded by vegetation. Fishes are commonly suspected of eating newts, but there have been many scientific studies of the food of freshwater fishes, revealing that such an event is in fact extremely rare.

Below: These smooth newts were found under a log in early March: soon they will set off on their spring migration to the pond.

Newt hunting in spring Each year there is a spring breeding migration. This is the mass movement of adult newts from their nearby wintering sites into the pond; it normally takes place during March. The weather at the beginning of the year is an important factor, and a mild year may find adults moving to the ponds in late February. Warm, moist evenings are the best times to go in search of newts on their spring migration.

Once the newts have entered the water you

can concentrate on watching their activities there. Some may be floating motionless in the water, near the surface but partly hidden by pondweed. By moving slowly and quietly around the edge of the pond, you may detect the quick movement of a newt swimming deeper in the water.

Newts mate and lay eggs in March or April, wrapping each egg individually in a leaf. The beautiful efts, or tadpoles, that hatch are about 2.5cm (1in) long and have frilly external gills that wave in the water as they swim. Unfortunately, efts are particularly vulnerable to the carnivorous larvae of dragonflies and certain water beetles.

Newts at night A good time to observe newts is at night. Take a torch, and be careful when approaching the pond because some newts may have ventured out of the water, on to the wet mud or grass near the water's edge. Once at the waterside, use the torch to scan the water near the edge, and you may see the newts swimming at the surface of the water. Move the beam of light gradually, for the sudden appearance of bright light disturbs newts.

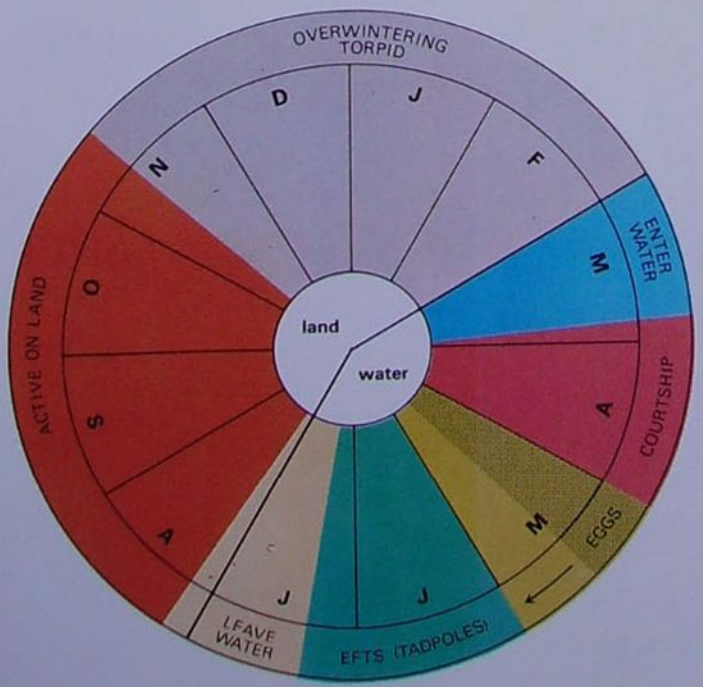
The behaviour of the newts at night varies with the species. The smooth newt often hangs motionless in mid-water, some distance from any vegetation; it also tends to occur in small groups of two or three. The palmate newt on the other hand moves slowly about in the water, and tends not to form groups. Great crested newts are found stationary in mid-water, like smooth newts, but they occur in larger groups.

After the breeding season When mating and egg-laying have been completed in spring, newts leave the ponds, so that throughout summer and autumn they are to be seen on dry land, although it is not easy to find them because they seek out cool, damp refuges. At this time of year they are particularly vulnerable to attack by predators, including hedgehogs, other small mammals and snakes.

In areas where newts are known to occur, it is sometimes possible to find them on summer nights as they wander about among fallen leaves and below low-growing shrubs. Torchlight may reveal them eating an earthworm or other small animal. They spend the daytime hiding beneath rocks, logs and other debris, or they seek the protection of cracks and crevices of old stone walls. From late autumn onwards, and as the cold weather approaches, the newts become more and more difficult to find because they are then far less active, and commence their winter period of inactivity or torpor.

Above: The palmate newt has webbed hind feet, lacks spots on the throat and the male (shown) has a tail filament. Body colour is no identification feature, but the smooth newt (below) does have the throat spots.

The varied year of the newt



Using an aquarium The courtship dance is a characteristic of newts. This behaviour is well worth observing, and anyone who possesses a freshwater aquarium is well placed to do so. Courtship is perhaps best seen in the smooth newt, and if these are abundant in a pond, it will do no harm to catch one or two pairs and transfer them to the aquarium. It is advisable to catch the newts early in spring, and to use a good-sized bucket or clean sweet jar when transporting them. Use this for returning them to their pond afterwards–newts should not be kept for more than a few days, unless the aquarium is extremely well equipped.

THE EARLIEST DAYS OF FARMING

In the first century BC British agriculture was generating a grain surplus which was traded on the European market—the culmination of centuries of large-scale clearance and cultivation which began in the late Stone Age.

Left: Wharfedale in north Yorkshire has been farmed for over 3000 years, and villages such as Linton and Grassington are surrounded by a network of field systems dating from the prehistoric, Roman, medieval and modern eras. The soils in these hilly areas, like those on the downlands of southern England, are light and easily cultivated, and were probably among the first to be cleared for agriculture by the Neolithic settlers.

In 1976 Britain experienced the hottest, driest summer for a hundred years. The grass was scorched, crops failed, and even trees began to suffer as the water level fell away. So extreme was the drought that, for the first time this century, archaeological features deep in the subsoil beneath the lowland arable fields became visible from the air as cropmarks. Deep-rooted plants, finding water in long-buried ditches and pits, remained green while their neighbours were burned brown, and the outlines of whole field systems and settlements reappeared, briefly mapped in green on the parched landscape. The pattern revealed was of prehistoric lowland agriculture on a vast scale.

Early days That most of these features were prehistoric was deduced from the shape of the fields: small square enclosures identical in form to surviving examples which have been dated to the Iron Age or before, at least 2500 years ago. This characteristic square field shape has been attributed to the technique of cross-cultivation associated with the primitive plough, or 'ard'.

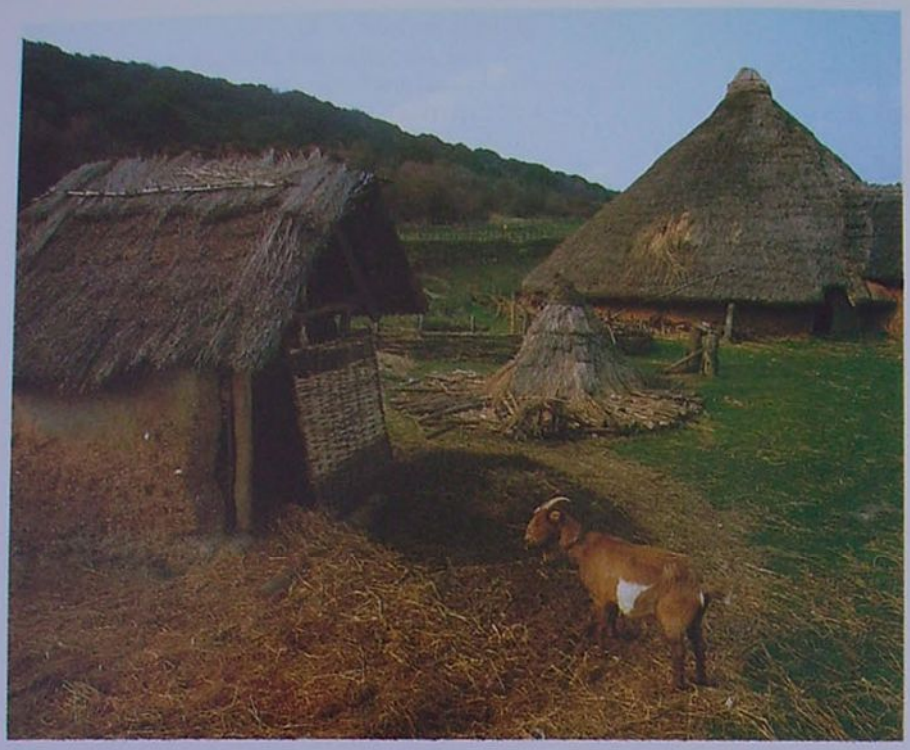
Until recently, pre-Roman activity in the fertile lowlands was attributed to an advanced culture which appeared in south-east England in the first century BC, apparently equipped with a heavy plough which could cope efficiently with the heavy lowland soils. It was assumed before this that the lowland clays of Britain remained uncultivated and probably under virgin forest until a few decades before the Roman occupation, while the farmers scratched a precarious living in the bleak hills.

However, there is no proof that such a heavy plough ever existed in pre-Roman times, and the evidence of the 1976 cropmarks has shown that the light ard could cope perfectly well with heavy soils too. This means that clearance of the lowlands could have begun as soon as the ard was introduced.

The earliest evidence of ard ploughing in Britain has survived in the form of criss-cross scratches scored into the subsoil beneath prehistoric fields. During excavation of the South Street long barrow near Avebury in Wiltshire a set of such traces was found beneath the structure, which was presumably built on a former field. The ploughing marks could be dated to about 3500BC. This is by far the earliest evidence of ploughing to have come to light in Europe, let alone Britain, but isolated as it is, it proves that the technology for extensive cultivation had been developed by the beginning of the Neolithic (New Stone Age) period.

Much more common are plough traces dating from the mid-Bronze Age (*c.*1500BC), and it is reasonable to suppose that in the intervening 2000 years the area of land cleared for agriculture had been considerably extended. Analysis of fossil pollen from all over the country indicates a marked reduction in tree

Below: Emmer wheat (*Triticum dicoccum*), a cereal widely cultivated in Iron Age Britain.



Above: The farmyard of the Butser Hill Ancient Farm Project near Petersfield in Hampshire. For over ten years crops have been grown, stored and processed using techniques suggested by the archaeological evidence. With only these very basic methods, researchers have consistently obtained wheat yields which are respectable even by modern standards, suggesting that the output of Iron Age Britain may have been much higher than was generally supposed.

pollen from about 3000BC onwards, and a corresponding increase in that of cereals, grasses and weeds of arable land. Cereal grain evidence of Bronze Age date recovered from Windmill Hill in Wiltshire suggests a considerable acreage of barley. Elsewhere, for example at Rams Hill near the Uffington White Horse in Oxfordshire, there is evidence of pastoral farming in the form of animal bones (mostly cattle) and fossil grass pollen. Long ditches have been interpreted as grazing boundaries, dating to the Bronze Age, suggesting extensive ranching on cleared land. In some places these ditches cut through complexes of square-type arable fields, demonstrating that organised large-scale agriculture was no novelty, even at this date.

Iron Age farming At around 500BC, the beginning of the Iron Age, there seems to have been a sharp increase in the rate of land clearance, judging by the pollen record. It is probable that many of the field systems revealed by the drought of 1976 date from this period.

More is known about the Iron Age than about any preceding period, but this is still very little. Pollen and crop remains indicate that Iron Age farmers grew a wide variety of crops including wheat, barley and beans–the components of the three-course crop rotation widely adopted during the medieval era. Employed in conjunction with mixed farming –for which there is ample evidence in the form of sheep and cattle bones–and consequent manuring of the fields, such a rotation would have permitted efficient cropping of the land over a very long period.

The grain crop, or a proportion of it, was stored in sealed pits which worked like modern silos–preserving the contents by excluding oxygen. Groups of these pits are characteristic of Iron Age farmsteads, and are usually the only substantial remains. The traditional building material was wood, which is biodegradeable, and after 2000 years little has survived of the structures except a rash of post holes, many of which are open to interpretation and will probably never be conclusively identified. This is unfortunate, for the structures they represent–haystacks, cornricks, granaries or pigsties–are a key to the Iron Age economy. If, for example, the existence of numerous haystacks could be proved, it would imply a considerable head of inwintered cattle, and probably restricted rough grazing on good land owing to extensive arable cropping. Current research at Butser Hill Ancient Farm Project in Hampshire suggests that Iron Age farms were very efficient.

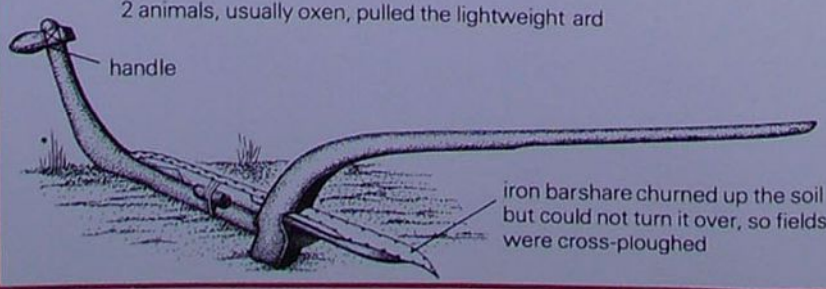
Julius Caesar's account of his expeditions to Britain in 55BC and 54BC contains passages which indicate a flourishing agriculture, and 45 years later the Roman geographer Strabo noted that Britain was exporting grain and cattle to the Continent. This implies the consistent generation of a substantial surplus.

The Roman Occupation We have no description of farming in Roman Britain, and no statistics. Parallels with other Roman provinces are useful, but sometimes misleading, since economic and agricultural conditions were different. As with earlier periods, most of the information about farming techniques has to be dug out of the ground.

Romano-British remains are spectacular when compared with those of the Iron Age, mainly because of the fashion for building in stone. During the first century AD, however, the villa buildings are little more than squared-off versions of the Iron Age farmhouses, often built on the same site and presumably occupied by the same family. At

The first plough

The primitive plough, or ard, is essentially a flattened spike that undercuts and disrupts the soil, but does not turn it over, so cross-ploughing was necessary–a process most easily achieved in square fields. In the past it was assumed that the ard was only effective on light soils, but modern experiments with replicas have shown that it was quite capable of dealing with heavy clay soils as well; and the drought of 1976 revealed square fields, characteristic of ard cultivation, on just such heavy soils. It is now apparent that large-scale clearance and cultivation of the landscape was a continuous process dating from hundreds, possibly thousands, of years before the Roman occupation, and probably started as soon as the technology–the simple ard–came into common use.



Above: By Roman times the lowlands were cleared for agriculture and probably looked much as they do today. Scythes began to appear in the first century AD. The ard (below) gradually evolved into the heavy plough which could slice and eventually turn the earth.

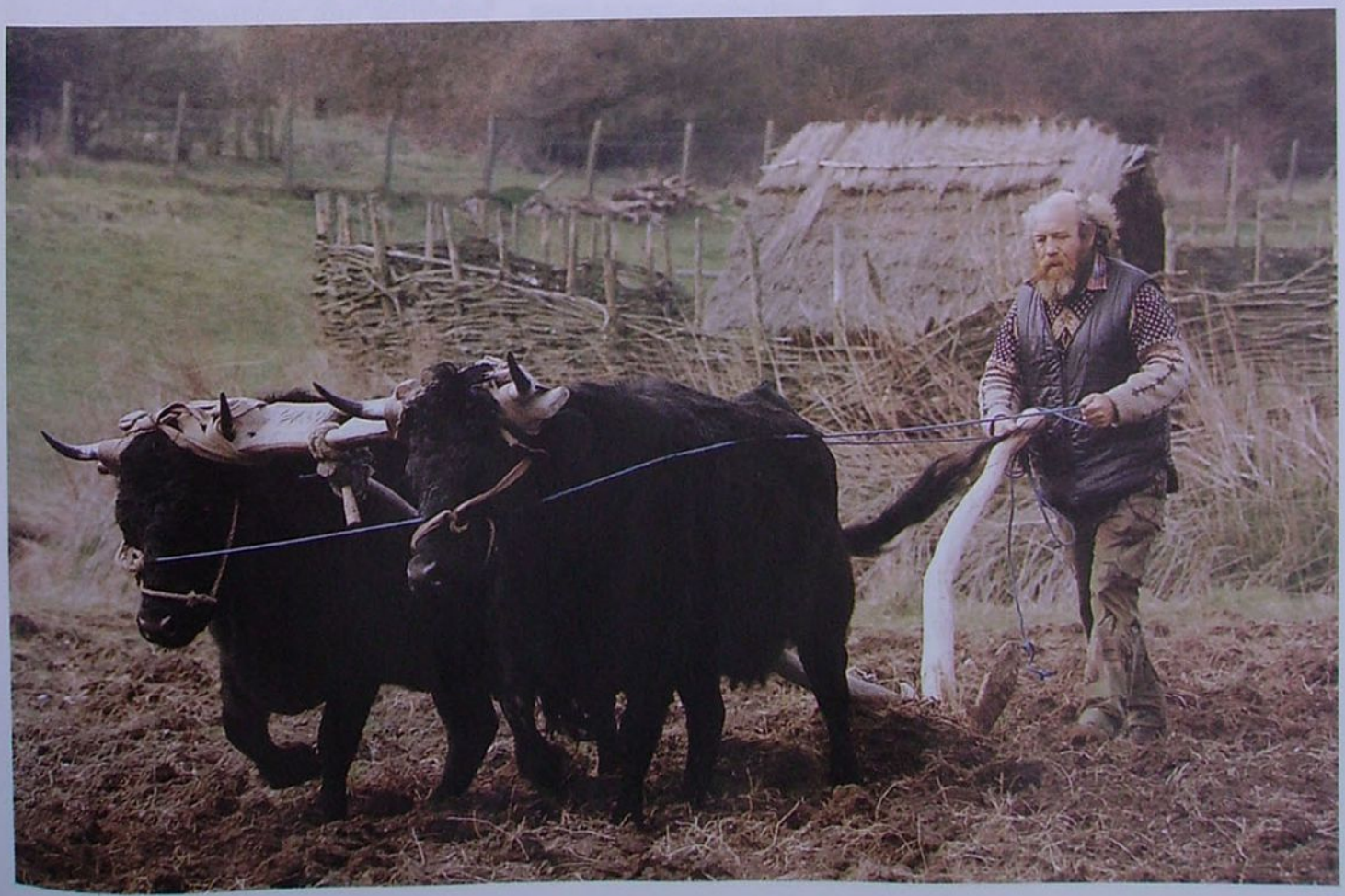
this time much of the farm produce was taken to feed the army, and at this period there was little money to be made from farming.

Estimates of pre-Roman productivity are still being revised, but there is no doubt that it was remarkably high. Nevertheless, the Iron Age-type farms persisted, complete with grain storage pits, while the simple ard continued in use, on square-type fields, right through the occupation: a tribute to a 300-year old technology.

When things settled down in the second century AD agriculture became more profitable. Instead of being merely a way of earning an income from an inherited holding, farming was regarded, probably for the first time in British history, as a way of obtaining a return on capital. The villas became larger and more luxurious. Under financial pressures they also became more productive.

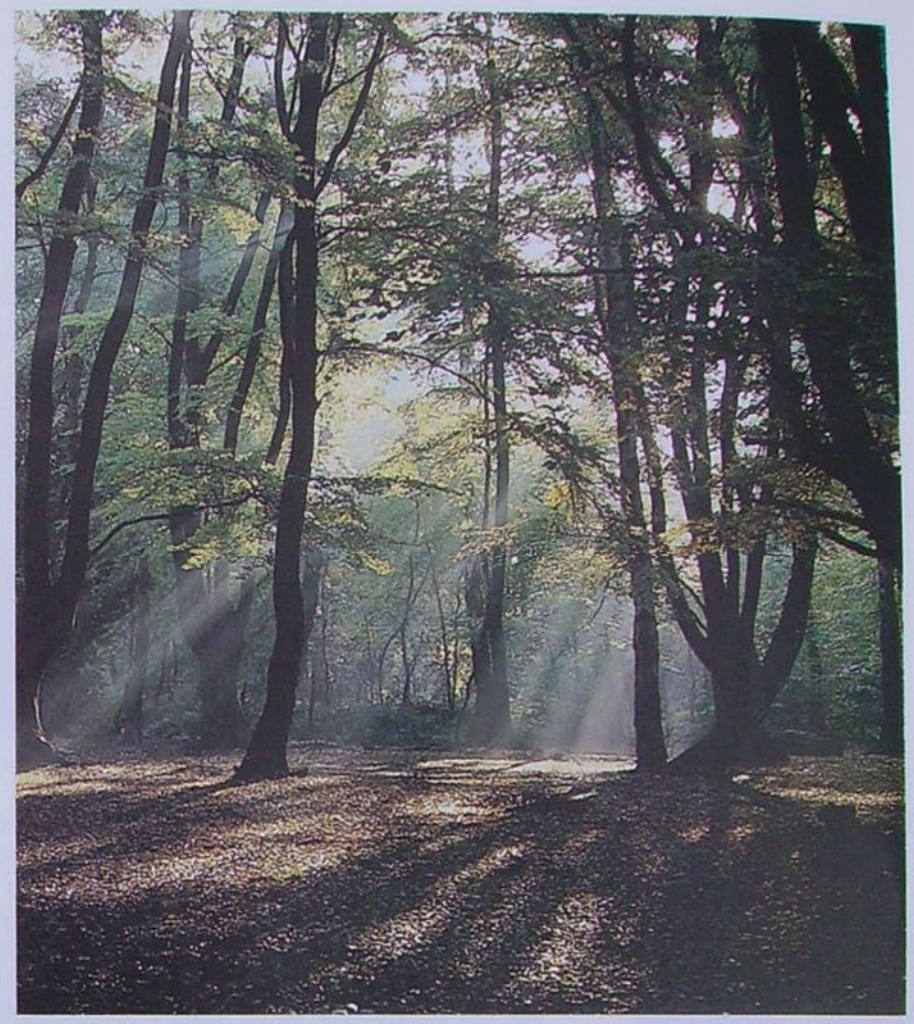
In due course new systems evolved. The introduction of the scythe suggests an improvement in the condition or numbers of inwintered stock. The practice of storing undried grain in sealed pits was phased out in favour of raised granaries, used in conjunction with grain driers. The heavy plough finally made its appearance and was gradually modified so that cross-ploughing became unnecessary. This would account for the existence of a number of long, rectangular fields of Roman date, some apparently formed by knocking out the boundaries between adjacent square-type fields.

By the time the Romans left in AD410 all the major farm implements of pre-industrial Britain had been invented, and much of the land cleared. The villa system collapsed with the breakdown of the monetary economy, but the estates continued to be farmed, probably in much the same way by both the native British and the incoming Saxon settlers. The system of peasant farming which they developed in the ensuing centuries was to become the foundation of medieval society.



WILDLIFE AMONG THE BEECHES

Beech struggles to compete with other trees but where it succeeds it forms magnificent woodlands sheltering some strange plants and rare animals.



Above: Ancient pollarded beech trees in Epping Forest.

After the last Ice Age, as the climate grew warmer, much of Britain was covered by forests of birch and pine which persisted until about 7000 years ago. Then the climate became wetter and the birch and pine gave way to forests of alder, lime, elm and oak. Beech was also present in those early mixed forests but, though widespread, it probably never formed forests of its own. Not until very much later, and then only in southern districts, did pure, or nearly pure, beech forest establish itself in Britain. It mainly occupied restricted localities in south-east England, reaching no further west than Dorset and no further north than Norfolk, athough it also spread into South Wales.

Why the coming of beechwoods was so long delayed and how they managed to find a niche in these districts is still a matter of conjecture. Did they come quite naturally, perhaps helped by some favourable but unknown changes in climate, or did they have to wait until man-made clearances in the primeval forest? What is generally agreed is that beechwoods date back no further than about 500BC.

Below: The edible dormouse occurs in the beechwoods around Luton, High Wycombe and Aylesbury. It feasts on beechmast.

Beechwood distribution Man has been interfering with woodlands for so long that very few, if any, can now be described as natural. Yet we can reasonably use the term semi-natural for woods occupying ground that has apparently been tree-covered for many centuries. Among the best known beechwoods of this kind today are those on the Chilterns and in the Thames valley. They also occur in a circle round the Weald in Surrey, Hampshire, Sussex and Kent, on the Cotswolds, on both sides of the Wye river between Monmouth and Chepstow and further west in the hills above Cardiff and in the Clydach valley near Abergavenny.

You can find beechwoods outside southern England and South Wales, but they are all known to be or assumed to be plantations. In southern England, too, there are undoubtedly many beechwoods that have been planted. For instance, fine stands grow in the Forest of Dean and in the New Forest. These are probably the result of oaks being cleared and beeches planted in their stead, for it is unlikely that beech managed to carve out a niche, unaided, in the heart of such ancient oak forests.

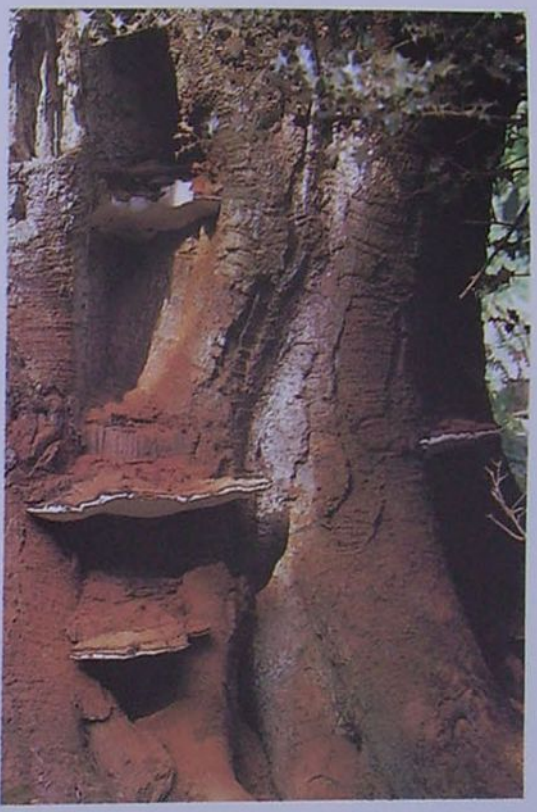
Struggle for survival Beech is an adaptable tree, able to survive on most soil types except the extremely wet and the extremely dry, but its main handicap is that on the majority of soils it cannot compete with oak. There are, however, three soil types on which beech

evidently has the advantage over all other trees: the shallow, lime-rich soils of chalky escarpments such as those on the Chilterns and of the oolitic limestone on the Cotswolds; the well-drained neutral to acid clay-with-flint soils found on top of the Chiltern plateau; and the limeless acid sands and gravels such as those in parts of Epping Forest.

In the struggle for survival beech suffers the disadvantages of producing a real abundance of seeds only at intervals of many years. (Such bumper harvests are probably caused by rare combinations of weather factors.) In contrast, trees such as oak, ash and sycamore yield larger quantities of seed more often. During normal years the comparatively few nuts which beeches produce are soon eaten by birds and mammals, so it is only in great 'mast years' that beechwoods have any hope of advancing on to neighbouring ground–should any space be available, which in these days of land shortage is becoming increasingly unlikely.

Specially adapted plants Beech is a leafy tree and its foliage is arranged in close-set layers, allowing little light through the canopy. Consequently the undergrowth is often very impoverished compared with, say, that of an oakwood. The plant life is also discouraged by the deep carpet of dead, slowly rotting beech leaves, and by the competition of the many beech roots growing close to the surface.

In the dark competitive environment only very specialised plants thrive. One group is the saprophytes, such as yellow bird's-nest and bird's-nest orchid, which can survive in a beechwood because they obtain their food from decaying plant material instead of from photosynthesis. Several other species of orchid, such as white helleborine, are also able to grow in beechwoods, not by being saprophytic, but by being mycorrhizal–their roots form a partnership with an underground fungus that helps to supply the orchids with food, especially in their early stages of growth.



Above: The beech weevil is a difficult insect to find because of its small size. Far more obvious is the damage it causes to beech leaves: the larvae feed as miners within the leaves while the adults feed externally.

Right: *Ganoderma applanatum*, sometimes known as artist's fungus, thrives on the trunks of deciduous trees, especially beech. These fungi have shed their spores as a mass of rust-coloured dust.

Below: When beechmast is plentiful hawfinches move in to take advantage. They are extremely shy, however, and once disturbed they fly up into the trees and are reluctant to come down again.

Flora in the clearings Not all beechwoods are uniformly dark beneath. Some have clearings or less densely packed trees, and in such sunny groves the undergrowth is noticeably richer. This is particularly true of steep escarpment woods where ash, oak, whitebeam and wild cherry grow among the beeches. In lime-rich soils the ground may be covered by dog's mercury, sanicle, or sometimes great carpets of ivy. Other common wild flowers are bugle, woodruff, dog violet, strawberry, yellow archangel, wood anemone and wood spurge.

On acid soils the plant life is different, however, and birch and rowan are likely to grow among the beech trees. Here in early spring there may be white carpets of wood sorrel, followed by bluebells in May. Slender St John's wort, wood sage, cow-wheat and wavy hair-grass are also scattered through the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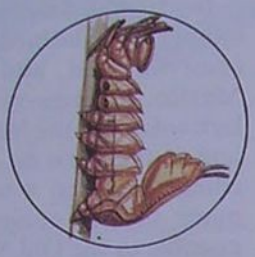
1 Hawfinch



2 Lobster moth

3 Beech tuft

4 Bird's-nest orchid

5 White helleborine

6 Solomon's seal

7 Death cap

8 Horn of plenty

9 Brambling

10 Edible dormouse

Left: The dense foliage of beech allows little light to penetrate through the canopy so the undergrowth tends to be sparse. Nevertheless beechwoods support a fair range of wildlife, noticeably plants that can survive the lack of light and animals that feast on beechmast. High up in the **canopy** shy birds such as hawfinches occur, though they do descend for the beechmast. Sharing these lofty heights are the caterpillars of the lobster moth with their fearsome 'faces', guaranteed to deter even hungry birds. Lower down the tree on the **bark** of the trunk the fungus, beech tuft, thrives. On the **ground** you may come across bird's-nest orchid which is a saprophyte, growing among dead and decaying matter. Another orchid that occurs in beechwoods is white helleborine, a species which prefers the shade. In contrast, Solomon's seal favours woodland clearings where the sun is able to penetrate. The deep leaf litter supports two more fungi: the deadly poisonous death cap and the edible horn of plenty. On the ground you may see a brambling searching for beechmast in autumn and–if you are in the Chilterns–the rare and alien edible dormouse.

Below: Yellow bird's-nest is specially adapted to grow in the dark conditions of a beechwood by feeding directly on decaying matter–it does not need to manufacture its own food, and consequently does not require sunlight for photosynthesis.

woods, and where the soil is even more acid the ground may be covered by bilberry, heather or bracken.

The deep beds of leaf litter in beechwoods provide rich feeding grounds for fungi. These are likely to be most abundant in beechwoods that also contain other tree species. Many fungi are mycorrhizal with the roots of beech trees, exchanging much needed soil chemicals. Among the characteristic fungi growing under beech trees are the yellow-brown *Russula fellea*, death cap and false death cap, horn of plenty, chanterelle and grisette. On the tree bark you may find beech tuft and the oyster mushroom.

Woodland animals The insects and invertebrates of beechwoods are many, occurring both in the leaf mould on the ground and high up in the trees. About 50 of the larger moths live on beech, some of the commonest being the vapourer moth, winter moth, November moth and grey dagger. Less common are the alder moth, the merveille-du-jour and the lobster moth with its grotesque caterpillars. The felted beech-scale, a tiny but very abundant insect, sucks the juices out through the beech tree's thin bark.

The mammals of beechwoods, especially where there is undergrowth, are much the same as those of other broad-leaved woods. But the one mammal thqt takes its name from this habitat, the beech marten, is not found in Britain.

One small rodent which occurs in beechwoods and other woods between Aylesbury, Luton and High Wycombe is the edible dormouse, an alien introduced from the Continent in 1902. Its presence in beechwoods can be partly explained by its diet, which consists of beechmast.

Feast of nuts Beechmast is also a favourite food of certain birds, especially the finches. In the autumn and winter of mast years flocks of bramblings and chaffinches feed day after day on the ground in beechwoods, pecking busily at the nuts. The breeding birds of closed canopy beechwoods are few but there are more in the open woods, for the shrub layer provides both food and nesting places for such species as thrushes, finches and warblers.

SHORE LARKS FROM THE WILDERNESS

The shore lark is a rarity in the British Isles, coming from some of the world's wildest places–the deserts of central Asia, and the tundras of the Arctic. Here, you can see it on estuary beaches in winter, and it breeds occasionally in Scotland.

Above: An adult male (left) and a juvenile shore lark.

Shore lark (*Eremophila alpestris*). Rare coastal winter visitor and passage migrant, sometimes breeding in Scotland. 16cm (6½in).

Looked at on the map of the world, the distribution of the shore lark is one of the most extraordinary among all birds. In the Old World it breeds in a narrow belt along the entire north coast of Europe and the Soviet Union and in a broader, discontinuous belt following the mountainous areas of North Africa and Central Asia across to China. Thus one part of its range is restricted to the Arctic and sub-Arctic regions (even in summer), and another part lies in the desert belt, across the northern Sahara and the Middle East to the Gobi desert in China.

In North America the picture is even stranger, for the bird is distributed there from coast to coast, and from Alaska south to Mexico. It seems most likely that the shore lark colonized the New World from the north, and as there are no other true larks there to compete with it, it was able to spread into a more diverse range of terrain than was possible in the Old World.

Harsh conditions Thus world wide, the shore lark is a bird of very varied habitats. In the British Isles it is found in habitats that most resemble these windswept, open landscapes. The area in which breeding occasionally occurs is among the high tops of the Scottish Highlands; more often it is seen as a passage migrant or a winter visitor, and at these times it is always on the coast. It favours sheltered sandy or shell beaches at the mouths of the estuaries, rather than beaches adjacent to the open sea itself. Most reports are of single birds or very small groups, and a flock in double figures would denote a birdwatcher's red-letter day. The most common feeding site is along the tide wrack of the estuary, where a mixture of small animals and plant seeds is available, some originating from the river and others from the sea.

The 'horned lark' The body plumage of the shore lark is as good for the purpose of camouflage as that of the skylark–a flecked mixture of browns and buffs above, paling below to a dull white breast and belly. This plumage is ideal for concealing the bird while feeding or incubating on the ground.

The head plumage, on the other hand, is far more striking. The face of both sexes is yellow, with a dark band running through the eye and down on to the cheek. On each side of the yellow forehead is a black band, running back above each eye and ending–in male birds–in a pair of upturned points rather like the waxed tips of carefully tended Victorian moustaches. Not always easily seen, as it is very prone to damage from wear and tear, this double crest is the shore lark's most distinctive feature and gives rise to the American name 'horned lark'.

Below a yellow throat is a broad black bib, shaped like the white crescent on a ring ouzel's breast. Juvenile birds have dark brown where the adult head pattern has black, and the young males do not have crests. Adults in winter may be rather more obscurely marked, especially at the beginning of winter, but from January they may be seen in full glory.

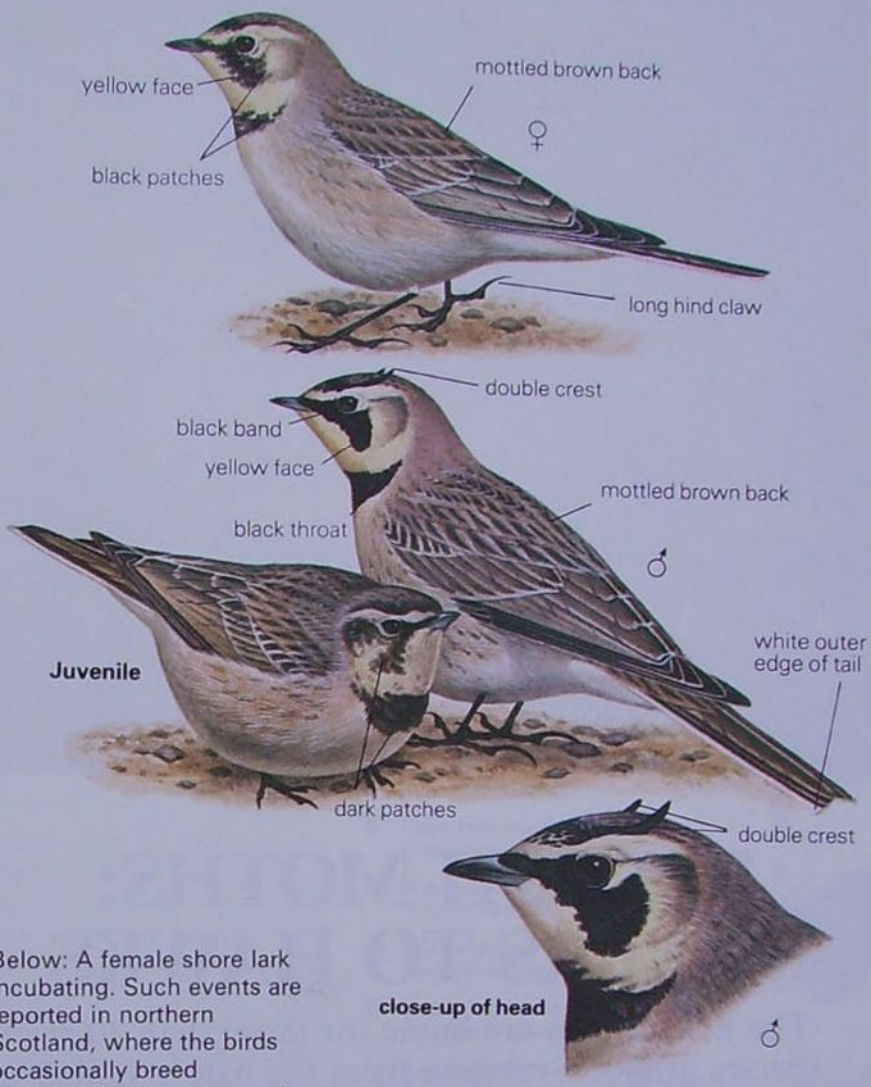
For all the striking appearance of the head pattern in a photograph or painting, the shore lark is among the least conspicuous of birds. It spends much of its time on the ground, running quickly between tufts of grass, and squatting when danger approaches. Only

The shore lark and its double crest

when an intruder is almost upon it does it fly, showing little in the way of distinctive features as it flits away, close to the ground in a deeply undulating flight path. Even its call is inconspicuous, resembling the 'seep' or 'tsip' of a pipit. Because of the very windswept nature of its habitat, the shore lark often sings best from the ground or a low perch like a boulder. Its song is quite similar to that of the skylark, but simpler in its range and structure, and more frequently repetitive.

Plentiful insects In all of its varied habitats, the shore lark is able to withstand hard climatic conditions (particularly chill winds and sudden snowfalls) without migrating elsewhere to breed. During the summer, particularly when young are being fed, insect food predominates over vegetable matter. In part this reflects the sudden summer 'flush' of insect life: perhaps the traveller's bitterest memory of a visit to any of the shore lark's habitats, particularly the tundra of the Arctic, is the swarms of blood-sucking midges, and to the shore lark they are an inexhaustible food resource. At the same time, this choice of food also partly reflects the need of the developing young for protein-rich foods, in common with many other bird species.

Increasing numbers For the last 20 or 30 years, despite occasional variations, there has been a slight but discernible increase in the numbers of shore larks seen on British coasts, either as passage migrants heading further south, or as winter visitors. In the early 1970s, signs of breeding were detected in some remote wilderness areas among the high tops of the Scottish Highlands. In such terrain, detailed observation and nest location for so secretive a bird proved difficult in the extreme, but by 1973 there had been many sightings of birds engaged in some of the typical activities of breeding birds–for example, carrying food to the nest or faecal sacs away–in the appropriate midsummer months. The calls of small young had been heard, too, in more than one case. It is to be expected that such occasional colonizations of suitable habitats in the far north will continue to occur from time to time: it may even be that this elegant and adaptable bird may make some inroads into the monopoly of the skylark on these desolate habitats. The shore lark is included in the list of British breeding birds, though as a marginal species.



Below: A female shore lark incubating. Such events are reported in northern Scotland, where the birds occasionally breed successfully; but you need an NCC permit to get anywhere near the site.

BRITISH MOTHS: MINERS TO HAWKS

The British Isles are home for more than 2000 species of moth, ranging from the barely visible leaf-miners to the hawk-moths–the largest of all our insects. Between these two extremes our moths exhibit a remarkable range of shapes and life-styles.

Despite comprising well over 95 per cent of Lepidoptera–the order to which both moths and butterflies belong–moths are poorly known when compared with butterflies. This is mainly due to their secretive nocturnal habits, for although some moths fly in the day the majority of the 2200 British species fly only after dark.

Large numbers of British moths are relatively small with wing spans ranging from a few millimetres to 2.5cm (1in). The giants among moths are the hawk-moths which reach a wing span of 12.5cm (5in) in some species. These are the largest of all British insects and equal birds in their manoeuvrability in the air. Some of our hawk-moths such as the poplar, lime and eyed hawk-moths are resident, while others are regular or occasional migrants. A number of our resident species, including the privet hawk-moth, have their numbers regularly supplemented by migration from southern and south-east Europe.

In some other families of larger moths it is mainly the males that fly. In the emperor moth, Britain's only representative of the Saturnidae, or silk moths, the multi-coloured males fly over moors and heaths during the day seeking the larger, greyish females. The latter are sedentary and attract males from a mile or more away by exuding scents called pheromones.

Males of some of the eggar moths (family Lasiocampidae) are also active during the daytime. Among them are the fast-flying fox moth and the oak eggar; both species are widely spread in the British Isles and occur mainly on heathland. The drinker moth is an eggar with less extrovert habits, and adults are sometimes found clinging to low vegetation in rough meadowland during the day, flying only at night.

Colours for survival Subtlety of colour pattern is typical of many moth families, among them the hook-tips (family Drepanidae) and members of the sturdy Thyatiridae. Most hook-tips are a rich brown with curved, tipped wings, although the Chinese character, when at rest in a hedgerow, looks very much like a white bird dropping. The family Thyatiridae include the common buff arches and peach blossom moths, both with intricate, colourful markings which are as aesthetically pleasing as any in nature.

In direct contrast with these are two families notable for their garish colours, by which they advertise their distastefulness to predators. These are the tiger moths (family Arctiidae) and the burnet moths (family Zygaenidae). The former include a number of day flying species which flaunt their contrasting black, white, red and yellow colours. Among these are the very common garden

Above: The attractively patterned Kentish glory moth is the sole member of the family Endromididae. It was once found in parts of southern England (as its name suggests) but now occurs only in the Highland and Grampian regions of Scotland.

Right: The hawk-moths derive their name from their powerful flight and their ability to hover while feeding at flowers. The small elephant hawk-moth, shown here, is one of the most colourful species and is found in virtually every part of the British Isles.

tiger, cinnabar and muslin moths. More widespread over heaths and moors are the wood tiger and the dusky reddish, ruby tiger.

Several species of the greenish-blue and red burnet moths live as large breeding colonies on railway embankments, notably where bird's-foot trefoil–the larval foodplant–occurs.

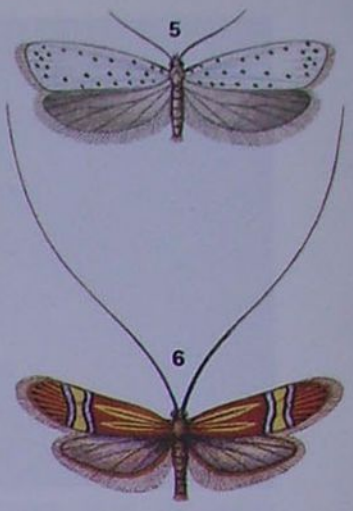
Noctuid moths Alongside the burnets in May and June are found several day flying members of the Noctuidae family–among them the mother shipton and the burnet companion moths. The former's name is prompted by the witch-like profile in the pattern of its forewings. Another familiar semi-diurnal noctuid is the silver-Y, often seen feeding from garden buddleia in the company of butterflies.

However, most noctuids, as their name suggests, are principally night fliers and many, like the very common large yellow underwing, are regularly attracted to light. Many species are well camouflaged in their natural surroundings, especially the marbled beauty and grey chi moths. Others, such as the impressive red underwing and copper underwing, display flash coloration by exposing their bright coloured underwings if disturbed by a predator.

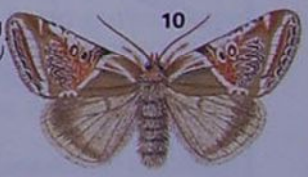
Colourful caterpillars Some moth families include species whose adults are far less striking than their larvae. Tussock moth

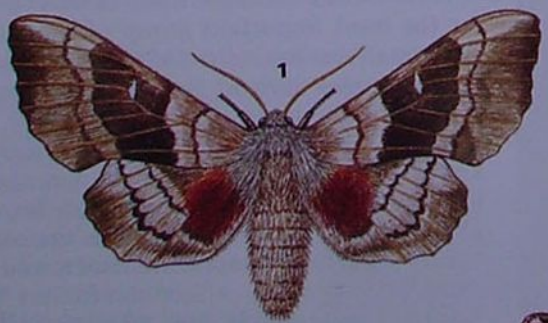
Principal moth families

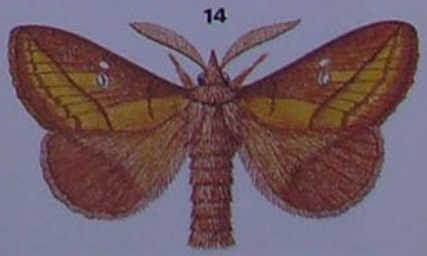
Order		Family	Common name	No. of British species
LEPIDOPTERA	Micro moths	Incurvariidae	Longhorn moths	25
		Pterophoridae	Plume moths	38
		Yponomeutidae	Ermine moths	67
		Pyralidae	Pyralid moths	158
		Tortricidae	Tortricid moths	306
		Others		787
			TOTAL	1381
	Macro moths	Hepialidae	Swift moths	5
		Cossidae	Goat moth	3
		Zygaenidae	Burnet moths	10
		Sesiidae	Clearwing moths	15
		Lasiocampidae	Eggar moths	12
		Saturniidae	Emperor moth	1
		Endromididae	Kentish glory	1
		Drepanidae	Hook-tip moths	7
		Thyatiridae	Thyatrid moths	9
		Geometridae	Geometers	295
		Sphingidae	Hawk-moths	19
		Notodontidae	Prominent moths	25
		Lymantriidae	Tussock moths	10
		Arctiidae	Tiger moths	32
		Noctuidae	Noctuid moths	353
		Others		5
			TOTAL	802



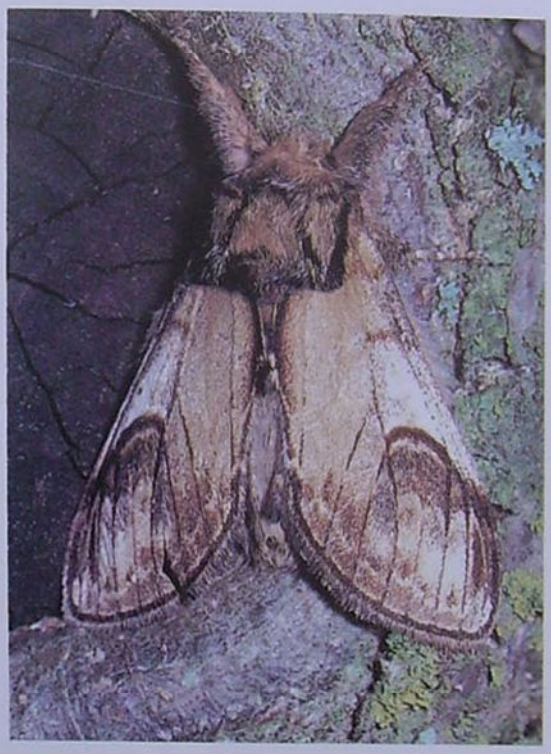
1 **Poplar hawk-moth** *(Laothoe populi)*
2 **Large yellow underwing** *(Noctua pronuba)*
3 **Garden tiger moth** *(Arctia caja)*
4 **Emperor moth** *(Saturnia pavonia)*
5 *Yponomeuta padella*
6 *Nemotois degeerella*
7 *Agdistis bennetii*
8 **Common swift** *(Hepialus lupulina)*
9 **Vapourer moth** *(Orgyia antiqua)*
10 **Buff arches** *(Habrosyne pyritoides)*
11 **Iron prominent** *(Notodonta dromedarius)*
12 **Red-belted clearwing** *(Conopia myopaeformis)*
13 **Green carpet moth** *(Colostygia pectinaria)*
14 **Drinker moth** *(Philudoria potatoria)*

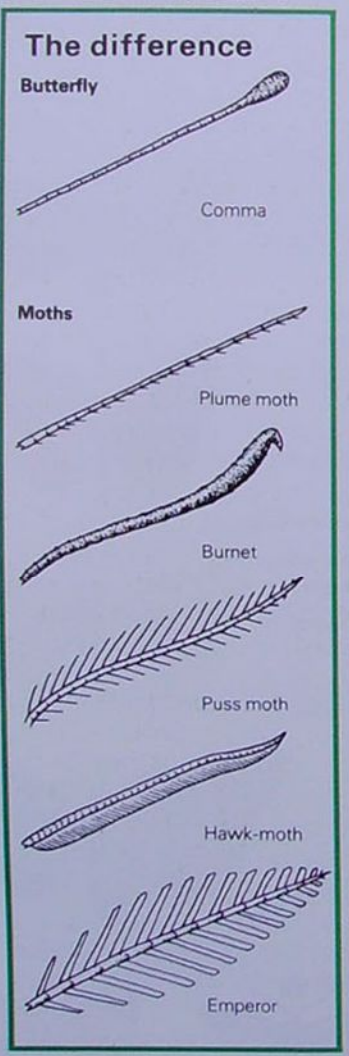






Above: This oak eggar and (right) pebble prominent show a familiar feature of moths–their hairy bodies.





Above: To distinguish moths from butterflies, look at the antennae. Those of butterflies have much the same shape and are always clubbed, while moth antennae are more varied and never clubbed.

Right: The bright colours of the scarlet tiger moth advertise its toxic nature.

caterpillars (family Lymantridae) are resplendent with toothbrush-like bristles on their back in a variety of yellows and reds. Other familiar examples of such colourful caterpillars are those of the pale tussock moth, once familiar when hops were gathered by hand, and the vapourer moth with its flightless female. Other well-known moths with striking caterpillars are the puss, alder kitten and lobster moths.

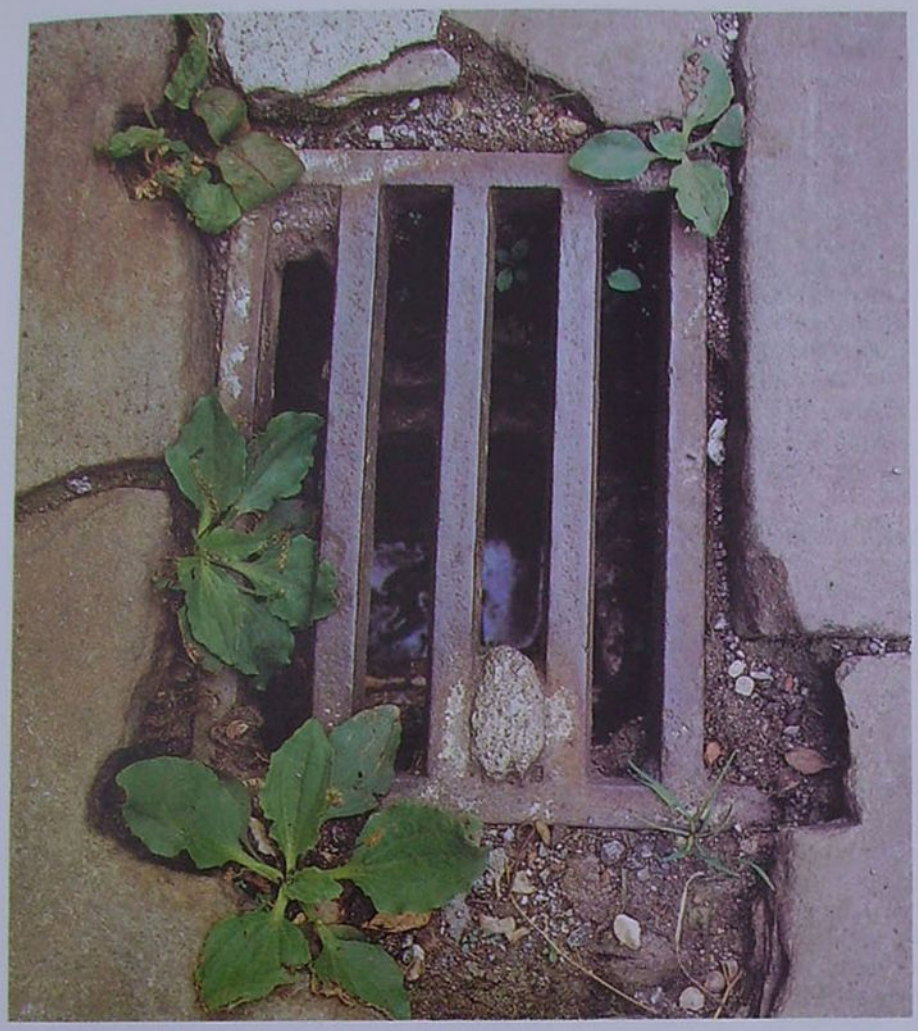
The Earth measurers One of the largest moth families is the Geometridae, so named because their caterpillars have a looping gait and seem to 'measure' the ground on which they walk. Britain's 295 species of geometer moths vary considerably in size. At one end of the scale are sturdy species such as the peppered moth and the large (but delicate) lemon-yellow swallowtailed moth which is a frequent visitor to artificial light in July. At the other end of the scale are the pugs, characterised by their narrow wings and span of 2cm ($\frac{3}{4}$in) or so. A middle range is occupied by the various species of thorn moth and the emeralds, waves and carpet moths.

Primitive moths The swift moths, clearwings and goat moths are classified together because they are all regarded as being primitive, sharing as they do several simple structures with each other. For example, all the pupae seem to have the legs and wing cases stuck on to the outside, whereas in other moths the pupae appear to have smooth surfaces.

Tiny moths A variety of smaller moths are loosely referred to as micro lepidoptera, although the distinction between these and the macro lepidoptera is not based upon any scientific grounds, the term being merely one of convenience. These families include a whole host of minute moths which have leaf-mining larvae. Not all the micro moths are tiny; some like the small magpie, garden pebble and mother-of-pearl moths are as large as pug moths. Far more typical are the tiny iridescent longhorn moths such as *Adela reamurella* and *Nemophora degeerella*.

Numerically the micro moth families are by far the most important group of moths but their small size has restricted their familiarity. Some families such as the plume moths are fairly well known to the country visitor, but many of the leaf-mining families are scarcely known even to experts. Some micro moths are important pests to gardeners and farmers alike, and include species such as the codlin moth, which infests apple orchards, and the small ermine moth, whose caterpillars spin extensive feeding webs over fruit trees.

In the home we find some destructive species such as the common clothes moth and the flour moth. Others have specialised to feed as larvae on wax, such as the aptly named honeycomb moth which depends upon the old combs in bee hives. One micro moth, the tobacco moth, has even turned its attention to eating tobacco in its larval stages.



PAVEMENTS: LIFE ON THE STREET

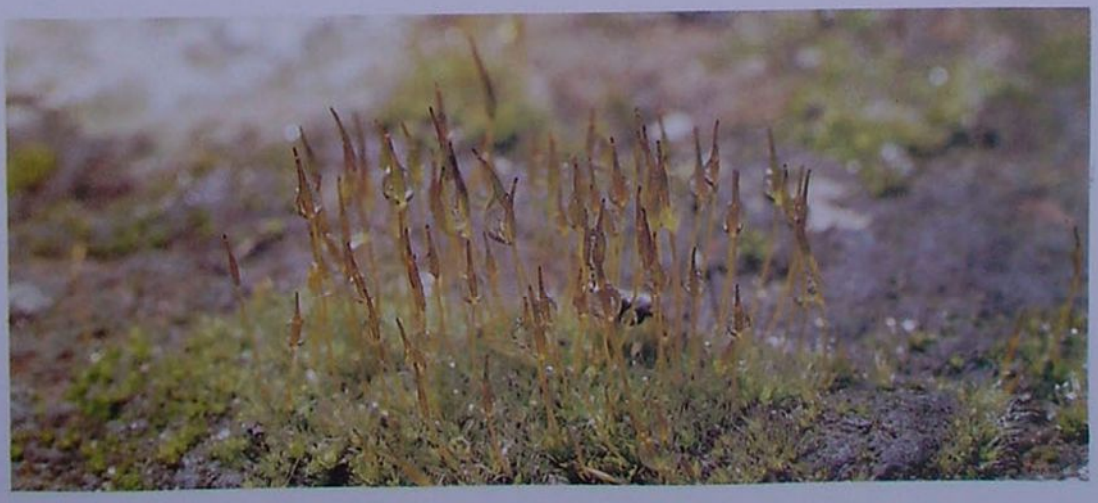
Among the many artificial habitats we have created in our towns and cities, pavements must seem among the least habitable. Yet, even there, beneath our trampling feet, plants and animals can survive and obtain enough food and water for their needs.

The pavement is a mosaic of different micro-habitats, some very harsh and others more hospitable to life. The harshest of all environments are the paving stones themselves. Only encrusting algae and lichens can survive on these, and even they are often killed by pollution from nearby houses, factories and passing cars, and also from being trampled underfoot. One species of lichen that can survive in such conditions, because it tolerates high levels of sulphur dioxide in the air, is *Lecanora dispersa*; in towns and cities it is black yet in rural areas it is white.

The parts of a pavement most favourable to life are the ribbons of soil between slabs and at the base of walls. Both habitats can build up high levels of nitrogen from the waste products of dogs, in contrast to the paving slabs themselves where these products are quickly washed away by the rain. Furthermore, the bases of walls are rich in calcium which is leached out of the mortar in the brickwork.

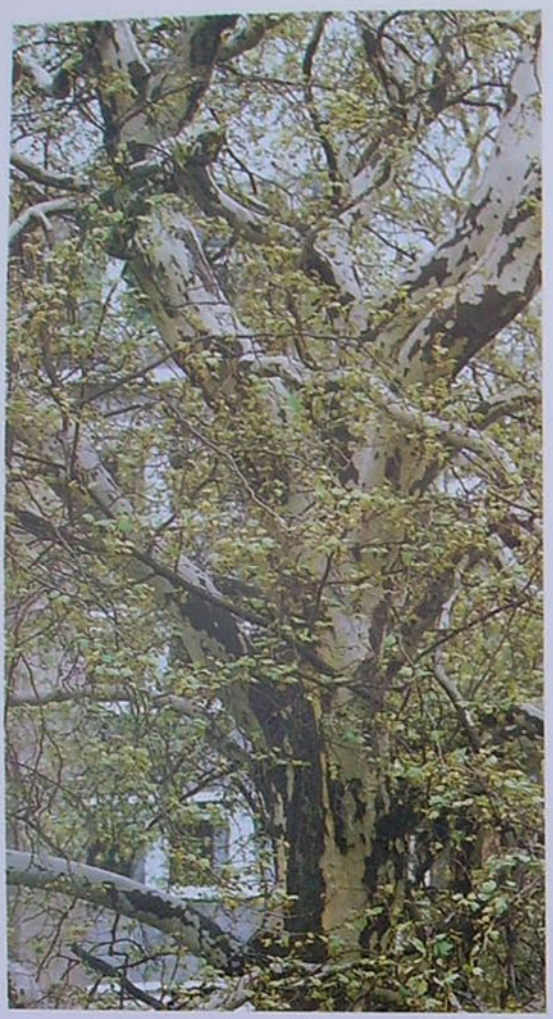
Extreme conditions Any plant or animal trying to survive on a pavement has to be able to tolerate extremes of heat. On a summer's day pavements heat up rapidly and, moreover, the buildings surrounding them (especially if tall) reflect the sunlight on to the pavements, increasing the temperature even further. At night they cool off just as swiftly and by dawn can be close to freezing point. Such enormous fluctuations in temperature within a single day can be tolerated by only a few plants, but the sow thistle thrives under these conditions. This species, a robust yellow-flowered member of the daisy family, is most often seen growing at the bases of walls. Here too can be found garden escapes such as snapdragons and wallflowers taking advantage of the nitrogen- and calcium-rich nature of the habitat, as well as the shelter it provides.

The extremes of heat are deadly to many of the animals living on the pavement. Therefore, during the heat of the day creatures such as slugs, earthworms and centipedes hide away under the paving slabs. In the country all these animals live beneath rocks and boulders; to them the paving slabs of the city



Above: Some parts of a pavement are more fertile than others. One of the best places for a plant to grow is by a drainage hole, where conditions are usually damp and where there is also likely to be a good supply of nutrients from the local dogs. The plants shown here are plantains.

Right: Some parts of a pavement quickly dry out. Wall screw moss survives this sudden drought by twisting its leaves to help retain water.



Water bears

Living among the thicker colonies of lichens found on pavements are water bears, minute primitive creatures perhaps no more than 0.5mm long. They are able to survive in such a hostile environment as that of a pavement by their ability to shrivel up and remain in this state for many months. As soon as water hits the pavement, they miraculously 'come alive' again.

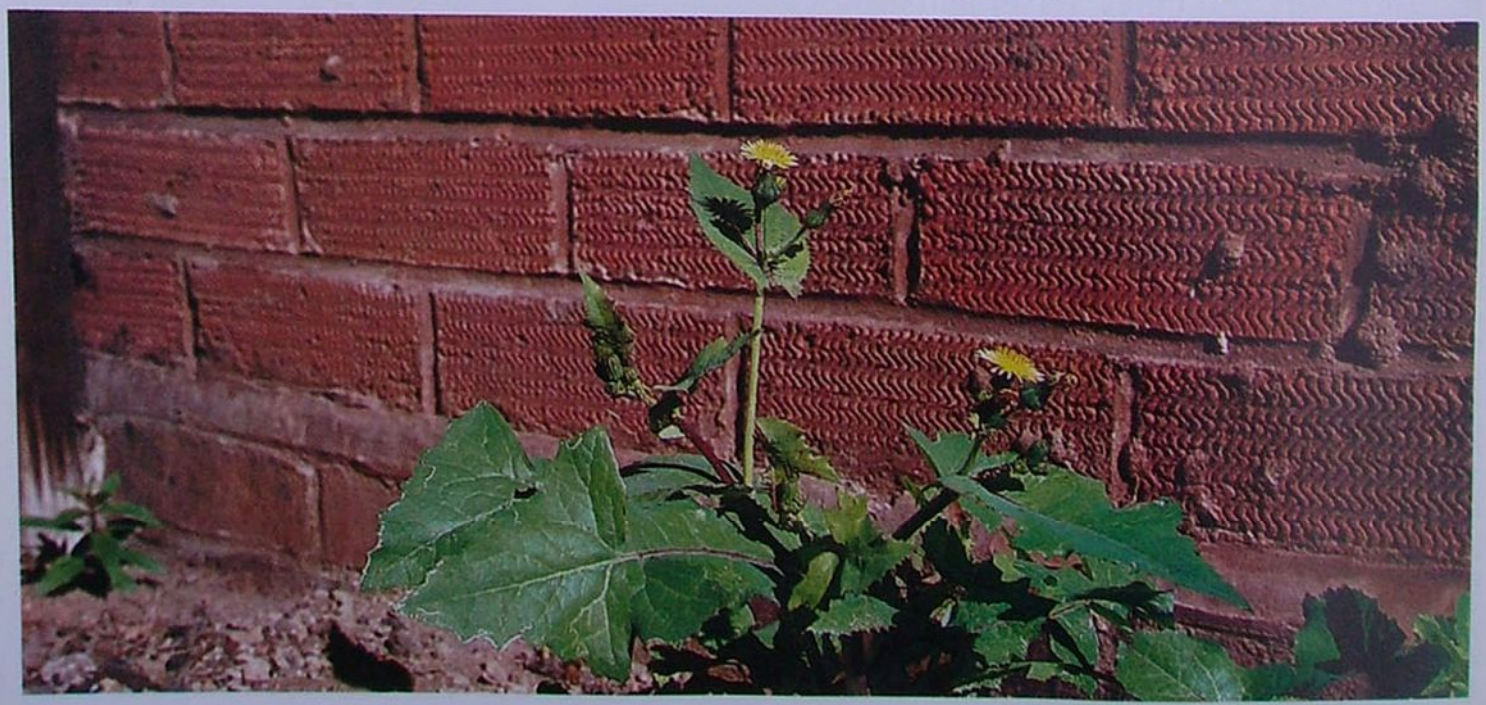
Left: Street trees suffer more than any other plants from soot and dust blocking their pores. One of the most successful in Britain, the London plane, partly overcomes this problem by periodically shedding large flakes of bark, taking the soot and dust with them.

Below: Take a close look at a pavement on a hot summer's day and you will probably see dozens of red mites scurrying around. From standing height, however, they are quite invisible.

Below: Sow thistle grows well on pavements at the base of a wall, where conditions are often damp and nutrient-rich. This species is one of the largest and most robust in the daisy family, growing to a height of 1.5m (5ft).

are simply an extension of this habitat. To appreciate fully the animal life of pavements a nocturnal sortie is needed. The concrete slabs, which were heated up during the day, lose their heat at night and become much colder than the air above. The consequence of this is that moisture from the relatively warm air condenses out on the cold slabs and enables soft-bodied creatures such as slugs and earthworms to emerge from their moist hiding places to feed. The slugs browse on the plants along the cracks and kerbs of pavements, while the earthworms search for dead leaves and other decaying matter to drag down into their burrows, where they will slowly feed on them the following day. The activities of both animals are visible the following morning as silvery trails of dried mucus.

The problem of feet Sow thistle and wallflower are tall fleshy plants that can survive only in a sheltered site such as close to a wall where they will not be trampled under people's feet. Out on the open pavement only low-growing, prostrate or rosette species can survive such rough treatment. Dandelion and knotweed, for example, are both low-



growing, robust plants capable of rapidly regrowing from side shoots after being extensively damaged. Mosses such as silvery thread moss keep low enough to be able to survive on open pavements. This moss rarely sets seed. Instead, small portions are accidentally broken off and kicked along by people walking. With luck the piece of moss becomes lodged in a suitable site for colonization.

These tussocks of moss provide a home for herbivorous springtails, which in turn attract their predators, the small rove beetles. As night falls these beetles are joined by their larger relatives, the ground beetles such as *Pterostichus cupreus* and *Harpalus affinis*, both of which are black. They scour the pavements looking for small creatures such as springtails to devour. Their larvae are also carnivorous and feed in the crevices between paving slabs.

The problem of dispersal Many plants that grow in between the stones and concrete face problems of reproduction and dispersal. There may not be another member of the same species close by, so cross-pollination becomes impossible, and there are also likely to be few suitable sites that a plant can colonize and thus perpetuate the species. Most of the more successful pavement plants overcome the first problem by pollinating themselves and the second problem by producing large numbers of wind-borne seeds, which are dispersed over the widest possible area so that the plant gives itself the best opportunity to colonize a new site.

One plant that follows both strategies is mossy pearlwort, a small green-flowered member of the campion family that persists between paving slabs, protected by the slight elevations of the surrounding stones. Mossy pearlwort frequently pollinates itself; later in the year it develops seed capsules borne on stalks. At first the stalks are bent down towards the ground to allow ants to carry away the seeds and thus disperse the species. After a while, however, the plant adopts an alternative strategy to increase the chances of its being dispersed: the stalks straighten up

Street scene

and the remaining seeds (which are almost as fine as dust) can be caught by the wind and carried away.

Many other plants have tiny seeds attached to a structure shaped to aid dispersal. That familiar urban shrub, buddleia, has winged seeds while dandelion and rose-bay willow-herb both have their seeds borne on parachutes.

Perhaps the most successful plant at dispersing itself is pineapple weed, a species that, since its introduction to Britain during the last century, has spread spectacularly throughout the country. Now common in the larger muddier gaps in pavements, pineapple weed produces tiny seeds that stick to the mud and

Above: Many of the most successful plants of pavements are annuals, which are quicker to move in and colonize a new niche than biennials or perennials. A prime example is pineapple weed, which soon spread through Britain when it was introduced here just over 100 years ago.

Left: Annuals have another advantage over perennials. Pavements can become extremely cold in winter and the safest way for a species to survive this period is as dormant seed, rather than as a plant, a strategy that is much better suited to annuals than perennials. Shown here is the annual grass, wall barley.

Below: Dandelion, one of the most familiar plants of the pavement.

are transported on people's feet and the wheels of vehicles. The latter have been largely responsible for the species' spread through the country. In one experiment a car with freshly washed tyres was driven around the Midlands for 100km (65 miles) after it had been raining heavily. It was then hosed down and the rinsings collected; when they were examined the rinsings were found to contain 220 seeds of pineapple weed, 387 of annual meadow-grass and 274 of chickweed. All three plants are typical of much-trampled rural areas such as farm gateways and footpaths as well as more urban sites.

Animal dispersal The need to disperse and find new sites to colonize is one reason why ants are the most familiar animals on our pavements. On one or two consecutive evenings around mid-summer the winged males and queens emerge from their subterranean nest. They enjoy a brief flight of freedom before mating and returning to their underground world.

The most common species to engage in these 'marriage' flights over our towns and cities is the black garden ant, *Lasius niger*. In its natural habitat it nests under stones and logs, but the modern expansion of paved areas has created an ideal artificial habitat for this ant. Here it finds the optimum conditions of high temperature, moisture and air that its grubs and pupae need if they are to grow quickly.

There is a plentiful supply of food for these pavement ants in the form of honey-dew, the sticky secretions produced by aphids feeding on the leaves of street trees such as lime, plane and flowering cherries.

If a pavement were allowed to go unchecked, without regular cleaning and repairs, a succession of plants would move in and it would slowly disappear under a layer of soil and vegetation. Man's activities prevent this from happening, instead maintaining the pavement at an early stage of succession. The result is an artificial, but unique, mixture of plants and animals, which find the patchy habitats provided by pavements ideal living places.

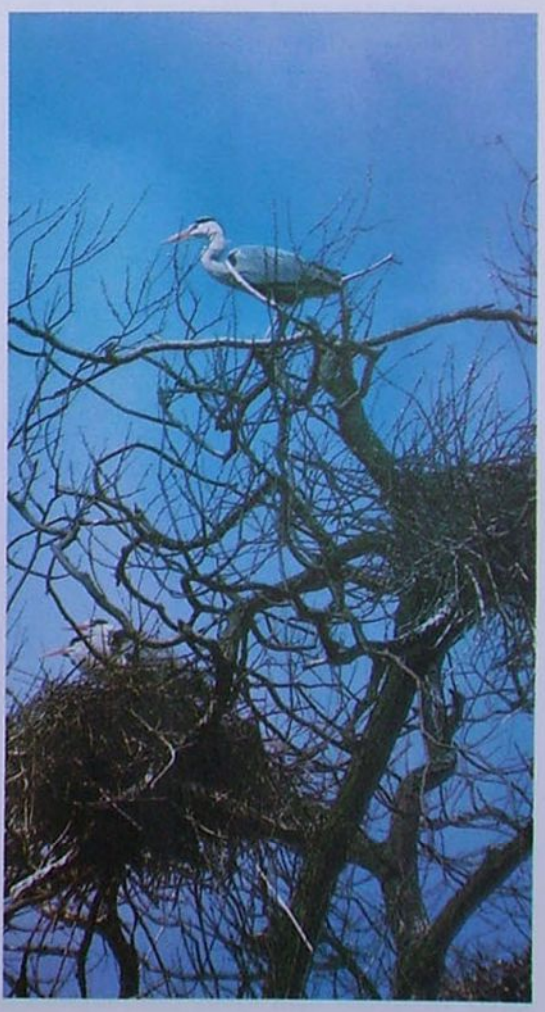
COUNTING THE BIRDS OF BRITAIN

Any birdwatcher who wishes to help find out the facts about bird populations–and help conservation efforts in the process–can join in a bird census; this might be a local count of selected species, or a national scheme such as the Common Bird Census.

Censusing birds may sound like a laborious task involving arduous days spent counting elusive birds in all weathers, but in fact it is great fun. This is evident from the large number of birdwatchers who take part in censuses; every month through the winter over 100 unpaid volunteers count wildfowl, while several hundred turn out on estuaries to count waders. During recent winters several thousand birdwatchers helped in the field work for the British Trust for Ornithology's atlas of winter bird populations.

How flocks are counted A large, very conspicuous bird such as the mute swan, which rarely occurs in flocks of more than 100-200, can be counted individually with great ac-

Above: A flock of over 2000 brent geese turns and wheels in the air: such changing formations confuse all but the truly experienced wildfowl counters.



Right: Like the majority of our bird species, herons are counted by partial census. In fact, they have the distinction of being the first British birds to be censused on a large scale: a partial count of herons was organised in 1928, estimating the total in England and Wales as 4000.

curacy. Geese, however, can form much larger flocks and these cannot be counted with the accuracy possible with swans. Going through a flock of several thousand geese in a field, one by one, would be a frustrating business during which one would be bound to lose the place several times. The usual technique adopted is to count in some larger unit, normally tens but occasionally fives and sometimes even 50s. The observer quickly becomes experienced in the visual technique of putting the birds into such groups as he scans the flock.

Counting hidden birds The Common Bird Census, organised by the British Trust for Ornithology, relies more on its observers' ability to hear and identify bird song than always to see and count the birds. The observers move quietly through their census plots, listening for the singing males of the different species, and plotting the localities of each on a large-scale map.

Not just for fun Counting birds is not just a matter of idle curiosity; it provides the bedrock of knowledge for a whole range of decisions about conservation. Those who are working to conserve threatened bird species need to know for certain which ones are increasing and which are declining. A census can yield useful clues as to precisely what is affecting the numbers, and in which areas. The factors could for example include changes in food supply, icy weather, drought, man's activities such as shooting or recreation, or some natural population cycle about which we need to learn more.

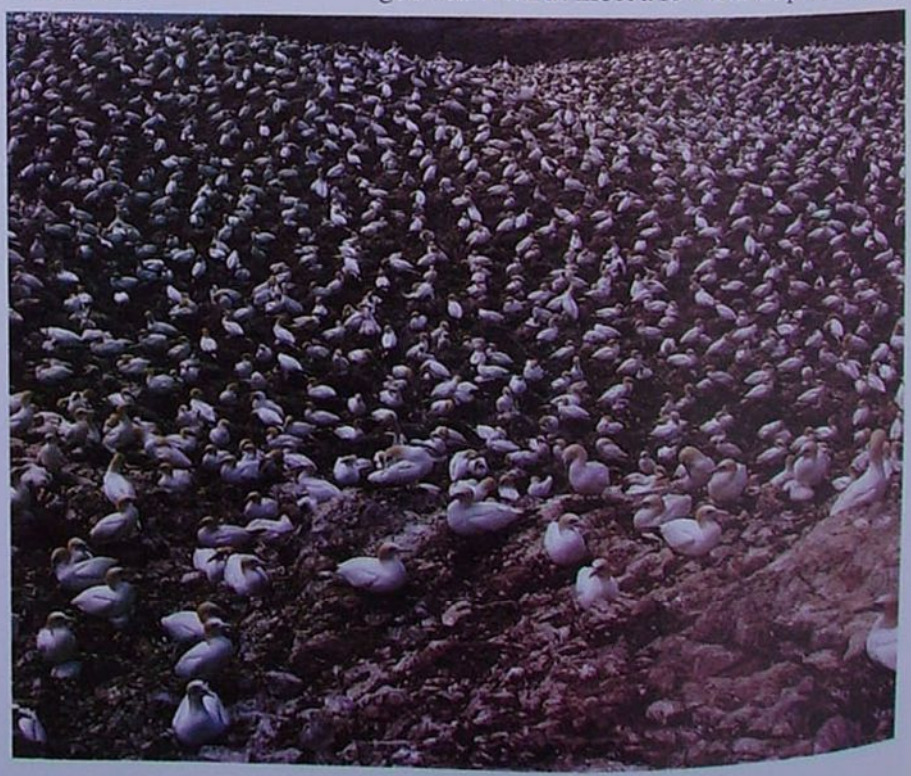
Certain birds can be used as environmental indicator species. In upland streams in Mid-Wales, for instance, dippers are being counted in a scheme run jointly by the water authority and the RSPB to monitor the effects of acid rain. If the dippers are shown to be taking up larger territories than usual, this indicates a decline in the abundance of aquatic insect larvae, on which the dippers feed. This in turn is strong evidence that acid rain has harmed the environment.

Above: Partial censuses of rooks have been carried out regularly since the early 1940s.

Above right: The Wildfowl Trust organises wildfowl counts every winter, including a complete census of the mute swan.

Below: A complete census of gannets is carried out every few years. The location of every gannetry is known, and because the nests are spaced out evenly counting is easy and accurate.

Complete censuses A complete census aims to count every single bird in a population throughout its range. Such a census is usually carried out on a relatively large or conspicuous bird such as the mute swan, the gannet or the great crested grebe. Very rare birds, too, can usually be counted completely, and at very regular intervals. The RSPB tries to monitor most of our rarest breeding species every year. These include the osprey, the bittern, the marsh harrier and the black-tailed godwit. With at most a few tens of pairs of any

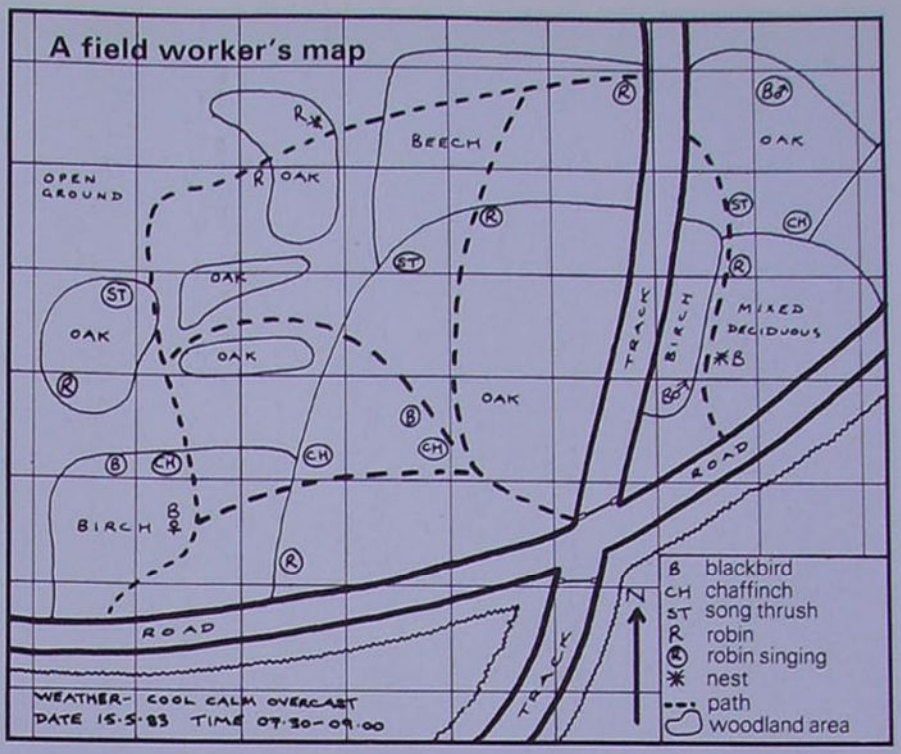


of these, all found in only a handful of localities, such counting is fairly straightforward.

Some such larger populations can also be censused completely, again because of their restricted range: geese are a case in point. Two species of geese, the pink-foot and the greylag, come to Britain for the winter from breeding grounds in Iceland. In the first few weeks after their arrival in autumn, they are concentrated in large flocks in a small number of locations, mainly in eastern and southern Scotland, and in northern England. For over 20 years a census has been attempted every early November, involving at most about 150 birdwatchers. During a single weekend these volunteers visit the areas allocated to them to count the geese, and although both populations number in the region of 100,000 birds, the counts are remarkably complete and accurate.

Partial censuses For the great majority of British birds, however, it is simply not possible even to contemplate a complete census. One would not know where to begin counting blackbirds, for example, or blue tits; and the same is true for many larger birds, including ducks and waders. For these it is necessary to take a small sample of the population of each species. While one may not learn directly from this method what the total population is, any changes taking place over a period of years can be detected.

The best example of a partial census is the Common Bird Census, which has been running for 22 years, involving annual estimates of the population changes of 60 of our commoner birds. The field work is carried out in more than 300 plots scattered over the country, and comparison with other scientific observations, including complete nest-counting censuses, has shown that the results are very reliable.



Above: An idealised version of a field ornithologist's map as made after an outing in the Common Bird Census. The field worker visits his area frequently in the breeding season, mapping the birds he sees. The 'scatter' of each male bird's song posts as recorded on his map reveals the extent of each territory. Estimates of population change are then made by comparing the number of territories in the plot with the previous year's results.

Breeding censuses A third type of census is more concerned with distribution than with actual numbers, though the latter may emerge from it, too. During the period 1968-72 the British Trust for Ornithology organised a breeding bird survey of the entire British Isles. Observers were not asked to count birds, but to try and prove breeding in each of the more than 3000 10km (6 mile) squares of the National Grid. Once one had found a breeding pair of a particular species in a square, then that record was sufficient, whether there was a colony of thousands of pairs, or a single nest.

Counting at speed

A flock of brent geese taking off (right) may be out of sight in less than a minute. Although part of the skill of wildfowl counting lies in taking care not to flush the birds, field workers develop an astonishingly quick visual technique for estimating the size of a flock if someone does frighten the birds. First, the field worker runs his eye briefly over the whole flock as it flies, gaining an overall impression. Next, starting from one end of the flock, he counts 100 birds at great speed, perhaps in 10s or 20s, and gauges how much space they take up. Then, equally speedily, he counts how many areas of similar size and density the flock contains. A useful aid is a hand tally counter, on which he presses a button at each 100: by the time he reaches 2000 it becomes very easy to lose count without such equipment. Experience plays a considerable part in such counting: the observer steadily improves his ability to estimate flock sizes in all circumstances, including poor visibility.

THE ARCTIC-ALPINES OF BEN LAWERS

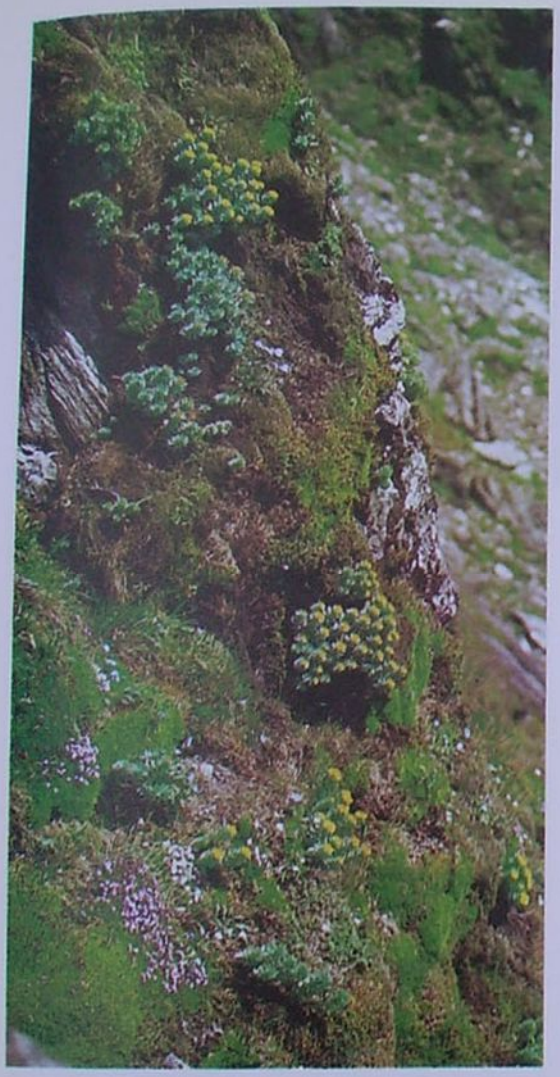
Most of the Scottish Highlands are covered by poor acid soils which support very few plant species. But the mountain of Ben Lawers, by the side of Loch Tay in Perthshire, is different, for its soils are less acidic, making it one of the best sites for alpine and arctic plants in Britain.

The unique soil conditions on Ben Lawers and its abundant mountain flora–in contrast to the rest of the Scottish Highlands–are explained by the nature of the underlying rock. This is composed of sediments laid down many millions of years ago when sea covered the area. These sedimentary rocks then sunk down towards the hotter centre of the earth, below the surface crust. When they were forced up again by a series of folding movements they formed a mountain range. Such great heat and pressure changed the nature of the rocks, however, and they no longer resembled sedimentary rocks–they were schists, and some contained semi-precious garnet stones.

These schists form one or two of the main soil types on Ben Lawers, and occur mostly on the upper slopes. The other main soil type is glacial drift–clays, sand and gravels deposited by glaciers when the ice retreated at the end of the Ice Age. Even within these two main soil types variations exist, for the effect of drainage and weathering in different parts of the mountain can be dramatic.

Leached glacial drift The sands, gravels and clays deposited by glaciers cover most of the lower slopes of Ben Lawers. These soils are usually impoverished, a state caused by rain water passing through a layer of humus on the soil surface and washing out (leaching) organic acids from the decomposing material.

Above: The summit of Ben Lawers, taken from neighbouring Beinn Ghlas. Ben Lawers is part of the Breadalbane mountain range, and lies near Aberfeldy in Perthshire. Rising 909m (3984ft), it has been required visiting for generations of botanists, ever since its flora was first documented by James Dickson in 1789. In contrast to most mountains in the Scottish Highlands, Ben Lawers is built of rocks which were originally composed of sediments and then subjected to intense heat and pressure. The resulting schists are finely fragmented rocks which have a tendency to split in one plane.



Above: Mossy cyphel, with its small green flowers, is a cushion-forming plant found on the rocky ledges of Ben Lawers.

Left: The rocky ledges, of which there are many, support some of the mountain's most interesting plants for the soils are rich in minerals. Here, nutrients in the soil are constantly added as a result of soil movement and rock falls, so leaching does not have the same impact as it does on other parts of Ben Lawers.

Below: Moss campion is an attractive alpine species with pink star-like flowers; it also thrives on the rocky ledges.

As this acidic water penetrates the depths of the soil it removes various soluble salts vital to the growth of a diverse plant community. The soil which is left is essentially a mixture of poor peat and sand and gives rise to an uninteresting vegetational cover dominated by mat-grass, a supremely acid-tolerant plant.

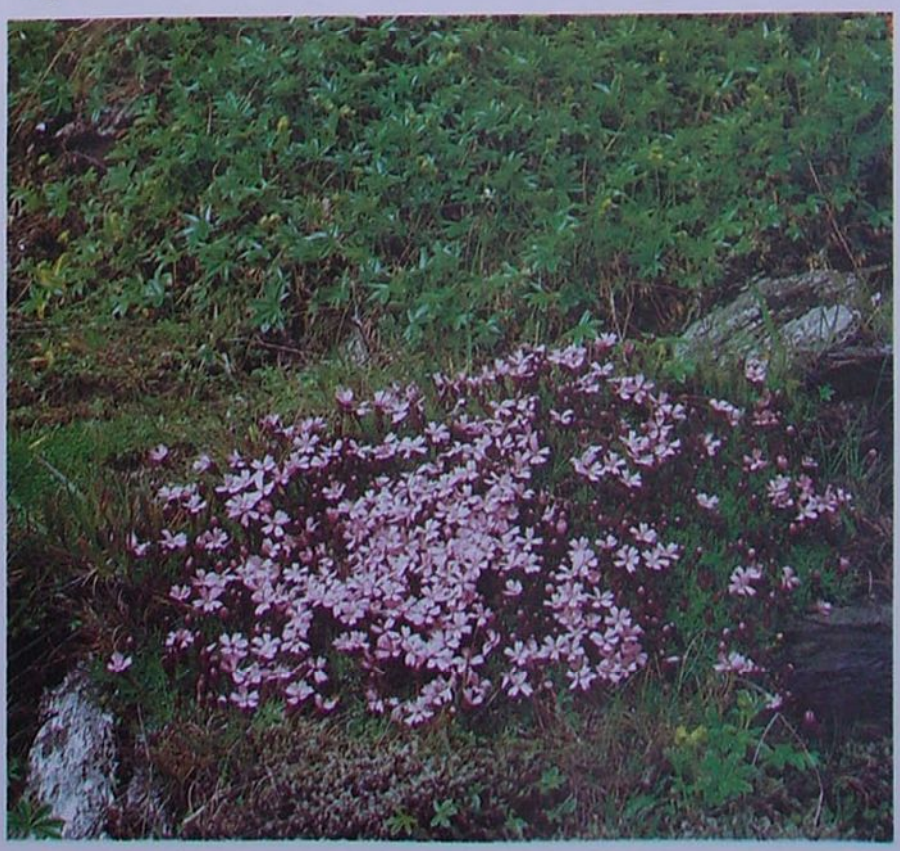
Sometimes these impoverished soils are constantly water-logged, making it possible for the acid-tolerant *Sphagnum* moss to grow. These water-logged areas gradually develop into full-scale bogs supporting cotton-grass and bog asphodel.

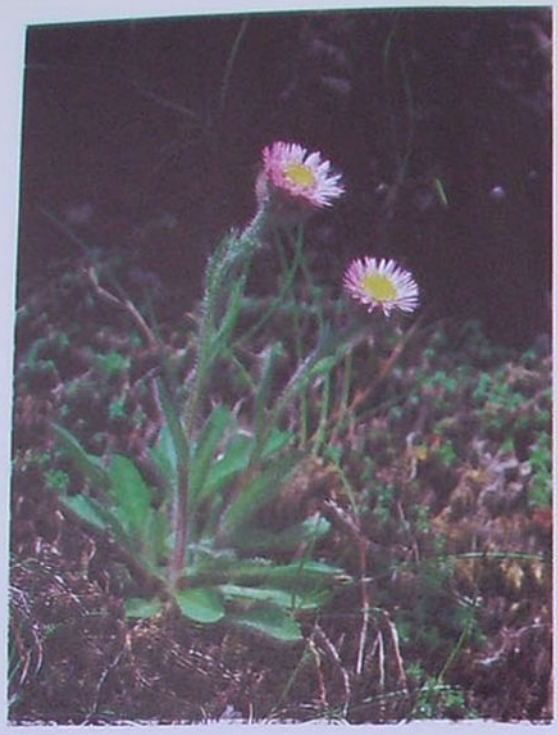
Flushed soils In some parts of the lower slopes the leaching out of minerals is compensated by the constant addition of minerals leached out of soils higher up, or by water carrying small pieces of rock that have been recently weathered away. This process is known as flushing. It may be seasonal, with meltwater from winter snows providing the extra nutrients; it may be permanent, as in areas where water comes to the surface and flows down; or it may be a dry process where the soil at the base of a scree is kept topped up by the simple process of gaining material from above.

Wet flushes–a result of the first two processes–contain the largest number of plant species, especially sedges and rushes. These are the most interesting glacial drift soils on the lower slopes of Ben Lawers.

Schist soils It is the soils composed of broken down schist, however, which provide a home for the particularly special plants of the mountain. As you climb Ben Lawers you will notice that the appearance of this more crumbly schist is marked also by the appearance of more varied plant communities. Alpine lady's mantle is one of the first plants to be seen, and on the less easily grazed areas it will often be joined by patches of moss campion with its attractive pink flowers.

Gradually ascending the slope you will also begin to notice the effect which the wind has on the vegetation. The wind is a great dehydrator, and the plants that survive it are some of the most highly adapted on the mountain. The moss *Racomitrium* is a characteristic plant of these conditions, and growing with it you may find the sedge, *Carex bigelowii*, a stiff-leaved plant. A few lichens





Above: In good seasons large numbers of alpine forget-me-not grow on Ben Lawers on the cliff ledges and also on the turf below.

Left: Alpine fleabane is an extremely rare plant, found only in certain parts of Scotland, growing at high altitudes on rocky ledges. In this country it was first discovered on Ben Lawers in 1789 by James Dickson.

Below: The rocks beside Lochan nan Cat, below Ben Lawers, support a variety of mosses and lichens.

may also be found as can the rush *Juncus trifidus* which occurs in the more sheltered spots.

Nutrient-poor communities on the schist, where much leaching is evident, are dominated by the ubiquitous mat-grass, present in patches that exactly mark the winter snow drifts which gave the plants protection. These poor soils are also characterised by an abundance of alpine lady's mantle, bilberry and various grasses and lichens.

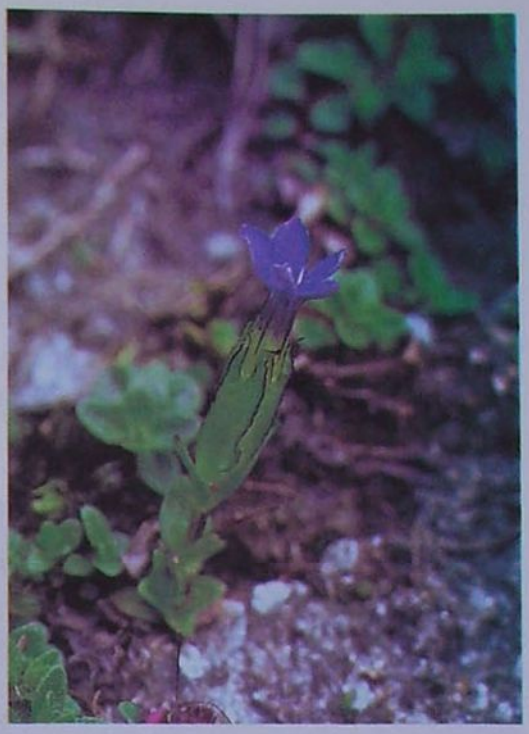
Rocky ledges As on the glacial soils, the most interesting habitats on the schist soils occur where flushing, or other pressures that delay complete leaching out of nutrients, happen regularly. One such habitat is rocky ledges, of which there are many on the upper slopes of Ben Lawers. A ledge may form at any time, simply by soil movement, or from the contents of another fall, as a ledge is washed away.

Some of the plants that grow here are natural cliff-dwellers, such as rose-root and alpine saxifrage, nearly always found pressed close against the rock. Other well-known plants include sea campion, mountain sorrel and the early flowering purple saxifrage. On certain ledges you may find alpine fleabane–a beautiful little plant–alpine speedwell, and one of the classic arctic-alpine plants, alpine mouse-ear chickweed.

The rocky ledges are also known to support two species of willows. These 'trees' never exceed 15cm (6in) in height, and are hardly recognisable as willows. The least willow is fairly common over the higher areas, but its relative, the net-leaved willow, is more particular in its distribution. This is also the larger of the two and, with its beautifully veined leaves, the more attractive.

Left: Drooping saxifrage, though long ago discovered on Ben Lawers, has hardly ever been recorded in flower, 1983 being an exceptional year.

Right: Snow gentian grows on the turf below cliffs where soil nutrients have accumulated.



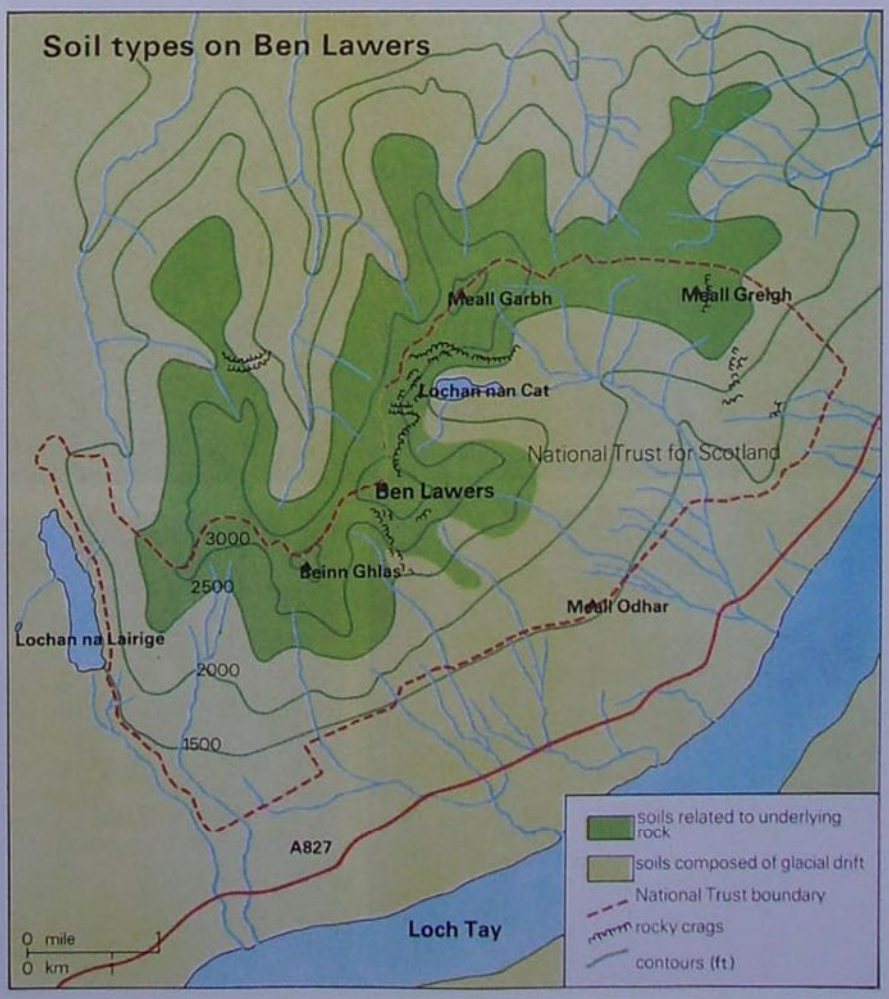
Below: A map of Ben Lawers showing where the two main soil types occur. On the upper slopes (the area shaded dark green) the soil type is directly related to the underlying rocks–mainly schists–and supports the most interesting flora. Lower down the mountain, however, the soil consists of debris brought from elsewhere by glaciers and then deposited (the area shaded light green). This includes sand, gravels and clays; the plant life is less exciting, the main vegetation cover being mat-grass. So, if you wish to see the alpine flora of Ben Lawers, you must be prepared for quite a climb.

More common mountain plants such as mountain cat's foot and viviparous bistort are also very common as ledge plants. Two cinquefoils–the alpine cinquefoil and its relative, least cinquefoil–are well represented and the ledges have some splendid plants of the cushion-forming moss campion and mossy cyphel.

On the cliffs that are most remote from grazing animals taller herbs such as globe flower, red campion, angelica and wood crane's-bill thrive quite happily, side by side with the alpine plants.

Fertile turfs Below some of the cliffs small flushed areas develop. They are surprisingly poorly off for grass species, with just a few interesting ones such as alpine meadow-grass and viviparous fescue growing. This is made up for by other plants, however, which form most of the ground cover. Among a profusion of such species as mossy campion, mossy cyphel and mountain pansy, grow two very special plants, snow gentian and alpine forget-me-not: snow gentian is a small species and our only annual member of the genus *Gentiana*, developing from seed to maturity in the short growing season on the mountain. Alpine forget-me-not is another small plant with large bright blue flowers. In good seasons this grows both on the rocky ledges and on the turf below. These turf plants have presumably arisen either from seeds dispersed by the wind, or from entire plants that have fallen from the crumbling, and unstable, rocky ledges above.

Summit species If you manage to reach the summit of Ben Lawers the soils appear to be no more than stone-yards with the usual grasses and sedges. On the summit the soil freezes solid over the winter and then, when it thaws, swells and flows creating a slow churning action, known as solifluction. This bizarre process–which occurs in the soils of the arctic tundra–creates small terraces of soil and brings stones to the surface from as deep as 1m (3ft). Any plant that can adapt not only to the rigorous climate of the mountain summit, but also the danger of these large soil movements, is a stayer of heroic proportions indeed.



TWO DAYS IN A BUTTERFLY'S LIFE

The story of a butterfly's early life–as an egg, then caterpillar, then chrysalis–is well known. Less familiar is its adult life: from when it breaks out of its chrysalis in the early morning, to when it dies of old age, only 48 hours later.

Above: The bulky body of this female marsh fritillary indicates that she has not yet laid her first egg batch.

Left: The chrysalis of a marsh fritillary and, above it, its black furry old caterpillar skin. When the transformation between caterpillar and chrysalis takes place the chrysalis is formed underneath the black caterpillar skin. This skin is discarded once the chrysalis is formed.

In a flower-filled meadow the first rays of sun are dispersing the mists of late May. Down in the vegetation a chrysalis of the marsh fritillary butterfly begins to wriggle as three weeks of apparent inactivity are about to bear fruit. Inside the thin but tough cuticle of the chrysalis a fascinating transformation has taken place: a black spiny caterpillar has been broken down into a thick chemical soup, and clusters of cells which have lain dormant in the caterpillar now regroup to produce an adult female butterfly.

Drying out The first signs of life show when a small tear appears in the front of the chrysalis as the butterfly pushes against lines of weakness in the cuticle. Her legs become free first, and soon after the rest of her body emerges from the chrysalis.

Between the time when the female butterfly emerges from the chrysalis case and the time when her wings are fully expanded and hardened she is extremely vulnerable to predators. For this reason she, and indeed many other insects, emerges in the early morning because at this time of day the nightshift of nocturnal hunters has ended and the onslaught of daytime predators has yet to gain momentum.

The bedraggled looking butterfly which crawls away from the chrysalis is a pathetic sight. Her instinct is to reach a secure perch where she can hang and expand her wings. This hardening and drying process may take one or two hours, during which time she must remain still.

This having been achieved, many butterflies make their first flight, but the female marsh fritillary crawls just a little further into the vegetation and settles with her wings folded back. This is to attract the attention of male marsh fritillaries.

Mating at an early age As with most butterfly species, the male marsh fritillary emerges one or two days before the female. At first the male spends his time perching on grass heads, flowers or conspicuous leaves from where he chases off any other males that come within 60cm (2ft). The males of other species also do this to defend a small patch of territory through which a female may fly. In the marsh fritillary, however, such behaviour serves no purpose as the females have not yet emerged from their chrysalids and, even when they have, they do not fly through male territory. One suggested reason for the marsh fritillary's behaviour is that it simply spaces the males out over the entire breeding area, ensuring that eventually all the emerging females are found. By the time the females do emerge the males have abandoned their perches and are quartering the ground in low zigzagging flights in search of females.

The female marsh fritillary that escaped from her chrysalis only an hour or two ago is now sitting waiting for one of the males to locate her. The male does this by sight, the female's outspread wings making her parti-

Above: Despite their conspicuous colouring adult marsh fritillaries are not much threatened by bird predators because of the poisonous nature of their bodies.

cularly conspicuous. Once the male has spotted the female he lands beside her and then walks around with fluttering wings. If receptive to his advances the female allows him to curve round his abdomen and mate with her. Mating takes a couple of hours, during which time the male passes a liquid from the tip of his abdomen to the tip of her abdomen. This liquid contains sperm and nutrients and is deposited within a tiny capsule called a spermatophore inside the female. Having passed across his sperm, the male then secretes a foam which he deposits in the female's genital aperture. This foam quickly hardens to form a very effective barrier to further matings. Mated females are easily distinguished from virgin females, for during mating the scales which covered the genital area of the female are dislodged to leave a bare patch.

A large batch of eggs In most butterfly species the mated female then flies away to mature her eggs. This does not happen in the case of the marsh fritillary, however. The female is adapted to a short life and when she emerges from her chrysalis 300 of her eggs are already fully mature. This large number of eggs presents the female with a problem, for their sheer weight and bulk make her body large and heavy–hardly suited to flying. Her flight is consequently restricted to a slow flutter as she searches low over the vegetation for a place to lay her egg batch.

Above: Marsh fritillaries mate with the tips of their abdomens coupled together.

Below: The abdomen of a virgin female on the right and a mated female on the left–the latter is recognised by the bare patch.

For this the female must find a large plant of devil's-bit scabious–the caterpillar's food-plant. The reason being that, once hatched, the tiny caterpillars (which feed together) must not run short of food before they are large enough to make the hazardous journey in search of another plant. In looking for a large plant the adult female relies initially upon sight but once she has spotted a suitable looking plant she will land to verify her find with her feet–at the tips of a butterfly's feet are tiny sense organs which respond only to certain chemicals, and confirm, for the marsh fritillary, that she has chosen the right plant species.

Once the female has chosen her plant she settles down to lay her batch of eggs on the underside of a leaf, near the mid-rib. She grasps the leaf edge and curves her body underneath it, depositing eggs at intervals of seconds in ordered rows until she has laid about 150. She then begins laying a second layer on top of the first, and eventually a third, the entire process taking about two or three hours to complete.

Afternoon relaxation By now it is early afternoon on the first day and our female marsh fritillary has finished laying her first, and possibly last egg batch. All the mature eggs have been deposited and she is now noticeably thinner. Inside her ovary, however, are further rows of eggs, though they are still immature and require nutrients which will swell them and turn them into mature full-sized eggs. Some of the material needed for their growth is already in the female as the fat-body, a type of insect liver, but others must be obtained through feeding. Whether these potential eggs ever reach maturity depends on the butterfly's feeding opportunities and life expectancy.

Some females do not live more than one day, and the average life expectancy is about three days. In the meadows where they live there are many predators, among which spiders figure most prominently. These spiders, mainly orb-web spiders, spin their webs between tall flower heads and catch some of the marsh fritillaries as they flit from flower to

flower in search of nectar to mature their eggs. In meadows which harbour marsh fritillaries you can often find spider webs littered with the parcelled bodies of these butterflies.

By the end of the first day our female marsh fritillary is still alive, having survived the dangers of predation and spent the afternoon feeding on yellow tormentil, buttercup, purple betony and meadow thistle. As night approaches she comes to roost under the leaves of a plant. A few adults bask in the late evening sunlight but they, too, soon close their wings. During the night her body changes all the nectar, which she collected the previous day, into useable nutrients for developing the remaining eggs.

Above: A spider feeding on a marsh fritillary butterfly. Spiders' webs, strung between tall plants, are one of the principal dangers an adult marsh fritillary must avoid if it is to survive its first day.

Above left: The female marsh fritillary lays her eggs on devil's-bit scabious leaves– the red eggs are a week old while the yellow eggs have only just been deposited.

Second day The first movement of the new day is when the female crawls into an exposed position and soaks up the first warming rays of the sun. Today she must complete the maturation of her eggs so she can lay another smaller batch. Her flight is now more purposeful as she is not restricted by the heavy egg load of the previous day. Yet despite this she does not wander more than 10m (30ft) or so away from her emergence site. This behaviour, common to both sexes of the marsh fritillary, helps to keep the colony in the same place year after year.

By the afternoon of the second day she is ready to lay another batch of about 130 eggs and once again she looks for a suitable plant.

The life of a marsh fritillary

1 Just before a female adult butterfly emerges from her chrysalis you can see her wings through the cuticle.

2 On emergence her wings are still deflated, and so she crawls discreetly to a perch.

3 Having found a perch she expands her wings and remains still for 1-2 hours so they can dry out and harden.

7 After mating, the female finds a suitable plant on which she lays about 300 eggs in a three-layered batch.

8 To mature her second batch, she must spend the afternoon feeding on the nectar of flowers.

9 As evening approaches she may bask in the sun. She then crawls down to the lower leaves of a plant and roosts.

By now an ideal plant may well contain as many as four egg batches, all laid by separate females. If our female chooses a plant which already holds an egg batch, she may even lay her eggs on the same leaf, adding her batch to the one already present. (One particular plant in a meadow in central England was recorded as holding as many as 1500 eggs.)

Last hours Once a female fritillary has deposited her second batch, she then continues feeding in an attempt to mature a third batch; very few females ever survive that long, however. Indeed, only one in three even reach the stage of laying their first batch.

While feeding the female may well be approached by a male with the intentions of courting her. As she has already mated she responds by flapping her wings at him–a signal that tells him that he is wasting his time. He will then fly off and try to find a more receptive partner.

Soon our butterfly will die. One of the greatest natural killers of adult butterflies is the heat and dryness of summer. Moisture–derived largely from nectar–is essential to the survival of butterflies, but as they age their body fluids are slowly depleted. Our female's life thus ends: it has been fruitful, but now her task is over and she dies of desiccation.

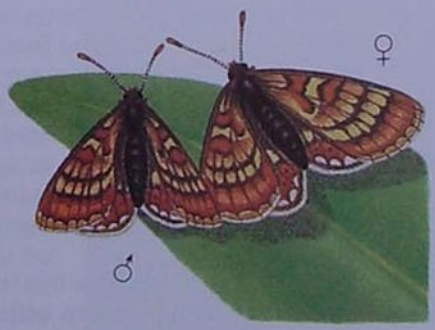
Such is the fate of many marsh fritillaries, but their place in the countryside has been guaranteed by the huge numbers of eggs left scattered in large batches.

Above: This marsh fritillary was disturbed by the photographer early in the morning. Since its body temperature was not sufficiently high for it to fly away (butterflies must bask in the early morning sun to raise their temperature before they can fly) it feigned death instead. This is another ploy for defending itself from predators. Such an action also exposes the butterfly's wing pattern which warns enemies of its poisonous nature.

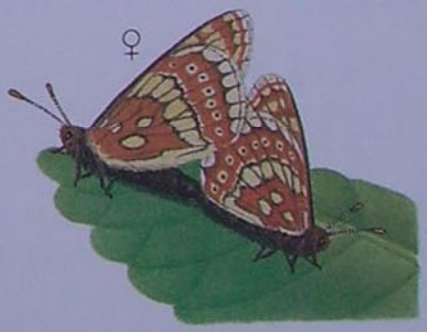
Life spans

Species	Sex	Adult life span
Meadow brown	both	3-12 days
Wall brown	both	4 days
Large heath	both	3 days
Heath fritillary	male	3-7 days
	female	2-6 days
Marsh fritillary	male	4-5 days
	female	3 days
Small blue	both	4 days
Common blue	both	3 days
Adonis blue	male	4-9 days
	female	10-12 days
Chalkhill blue	male	6 days
	female	4 days
Wood white	both	8 days
Lulworth skipper	both	6-7 days
Silver-spotted skipper	both	8 days

4 Now ready for mating, she spreads out her wings and raises her abdomen to attract a passing male.



5 With luck, a male marsh fritillary then lands beside her with his wings fluttering, and encircles her.



6 The pair mate with the tips of their abdomens coupled together; they remain like this for about two hours.

10 The following morning, she basks in the sun to raise her body temperature; she may also do this in the evening.

11 Even though she has already mated, she may well be harassed by males so she flaps her wings to put them off.

12 Death arrives for a butterfly in a number of guises: in this case our female has been caught by a spider.

ROTIFERS: LIVING JEWELS

Rotifers, a prolific class of tiny animals with apparently endless variety and beautiful intricacy of form, never fail to fascinate the microscopist.

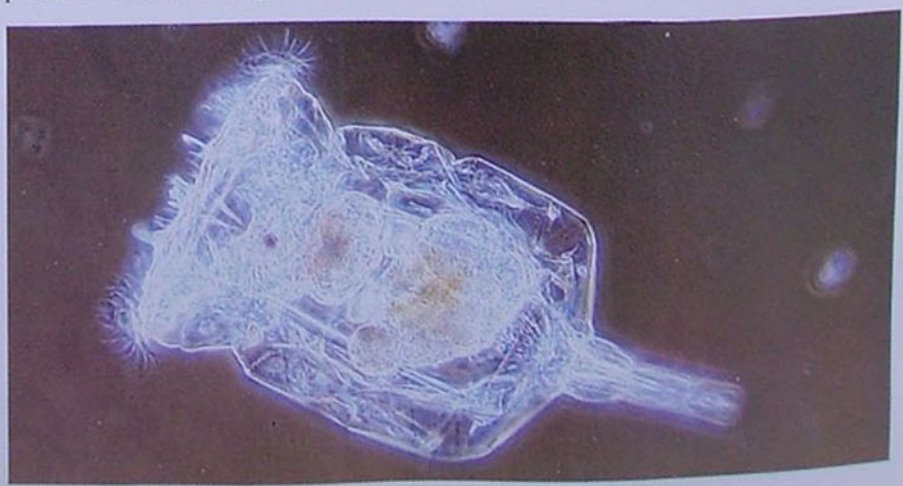
Rotifers, or wheel-animalcules as they were quaintly named by naturalists in earlier centuries, rank among some of the most extraordinary animals with which we share this planet. Scarcely noticeable without the aid of a microscope, they are nevertheless extremely abundant. A careful search of a pond could reveal up to 40 rotifer species, and individual numbers could reach 5000 in every litre of water. Such are their powers of reproduction that the millions of individuals of any rotifer species in a lake might be derived from a single original rotifer, introduced by the wind or by an animal.

Intricate anatomy Rotifers (literally wheel-bearers) derive their name from the characteristic wreath of cilia surrounding the head: in some species these do give a good illusion of a cog-wheel rotating. The body is usually divided into a head, trunk and foot, although the foot may be lacking. Some rotifers can withdraw the head and foot into the trunk, which may be protected by a hard covering, often ornamented with ridges or spines. The cilia on the head set up currents in the water which are used both in feeding and locomotion.

Rotifers feed on particulate matter—ranging from bacteria and detritus to other rotifers! Specialised sets of jaws break up the food before it is absorbed in the stomach. They possess muscles, organs for excretion and

Above: This weed-dwelling rotifer, *Trichocerca*, has pierced the cell wall of a filamentous alga and eaten most of the nutritious chloroplasts inside. The long spine is an elongated toe, used partly for swimming and partly for defence—it makes the rotifer harder to swallow.

Below: The swimming rotifer, *Brachionus*, is 0.36mm long. Its foot, on the right, has two short toes; the red spot on the left is its eye.



reproduction, and a system of nerves connecting to a brain. Although no rotifer exceeds 2mm and some are smaller than single-celled protozoans, they contain 400-1000 nuclei and have quite a complex organisation.

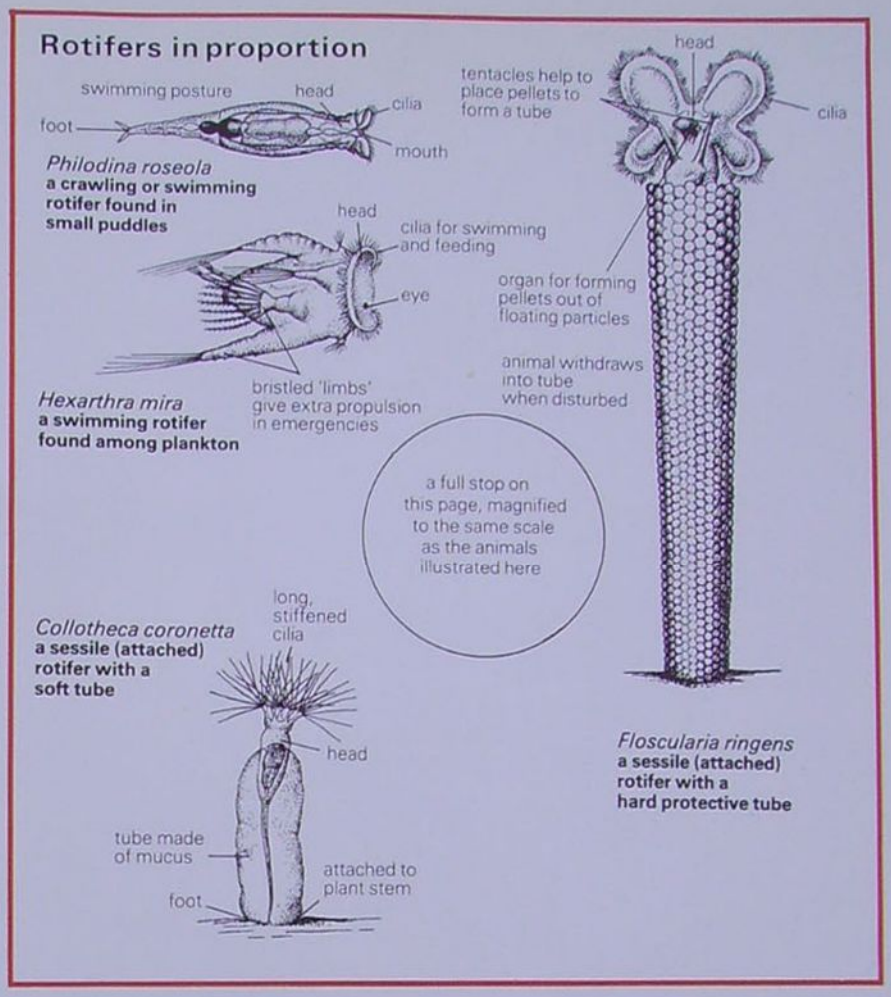
Living in water Rotifers can be found anywhere that is wet–not just lakes and canals, but even in places that are only occasionally wet, such as gutters and bird-baths, or even patches of mosses and lichens. Although they are most common in fresh water, about 200 species occur in brackish or salt water, though only about 15 are strictly marine. Most species can live in any part of the world that provides conditions specially suited to them. Some species are commensal or even parasitic; one lives inside colonies of the alga, *Volvox*, and another inside the cells of *Sphagnum* mosses.

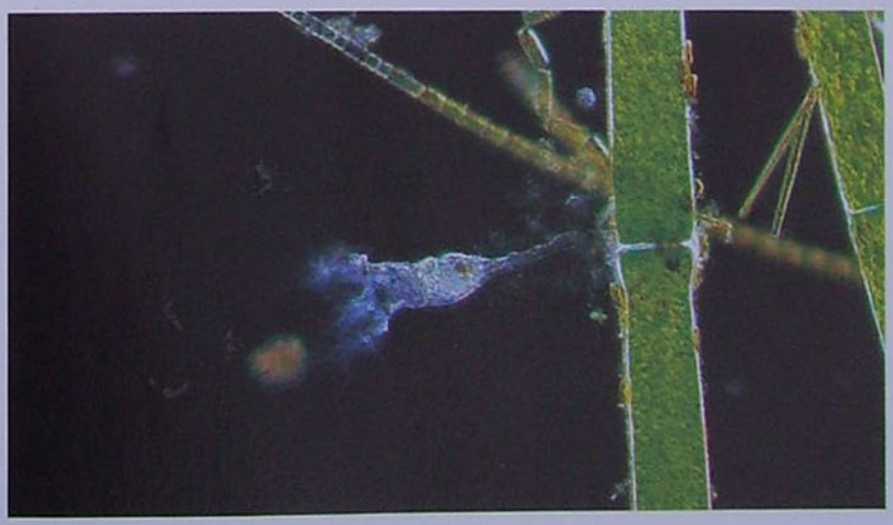
Ways of breeding Only exceptionally does the microscopist come across a male rotifer. This is because they are small (only two-thirds to one-quarter the size of a female), live only for a few hours, and are produced only very occasionally. Indeed, males are known in only some 400 species. Most of the time females produce eggs that hatch, without being fertilised, into female offspring. Sometimes, however a chemical or environmental trigger, such as a change in the length of daylight, leads to the appearance of females, called mictic females, that lay a different type of egg that will hatch into a male.

Male rotifers are not only small but are degenerate in that they lack digestive and excretory systems; they are really little more than a swimming bag of sperms. When they have found and fertilised a mictic female their job in life is done and they shortly die. Fertilised mictic females produce a third, special egg with a thick shell that is capable of surviving for long periods and can resist harsh and drying conditions until hatching into an ordinary asexually-reproducing female. These so-called resting-eggs allow the species to be dispersed, by wind or animals.

Sessile rotifers A number of species live their lives attached to submerged plants. These, the sessile rotifers, must catch and trap passing prey, either by setting up powerful currents with their cilia to draw prey towards their mouths, or by actively closing around them a net of stiffened cilia. Most sessiles build tubes in which they live, and when danger threatens they can swiftly retreat inside. The tubes are mainly built of mucus but *Floscularia* constructs a home out of hundreds of pellets–particles of floating detritus selected from the plankton and cemented into place.

Creeping rotifers The bdelloid (pronounced 'delloid') or leech-like rotifers form a group on their own: a typical example is *Philodina roseola*. They are so named because, in addition to swimming, they can also loop along like leeches or caterpillars. They have elongate bodies with two circles of cilia on their heads. They are capable of contracting so that they become barrel-like, with head and foot withdrawn into the body. They are extremely common.



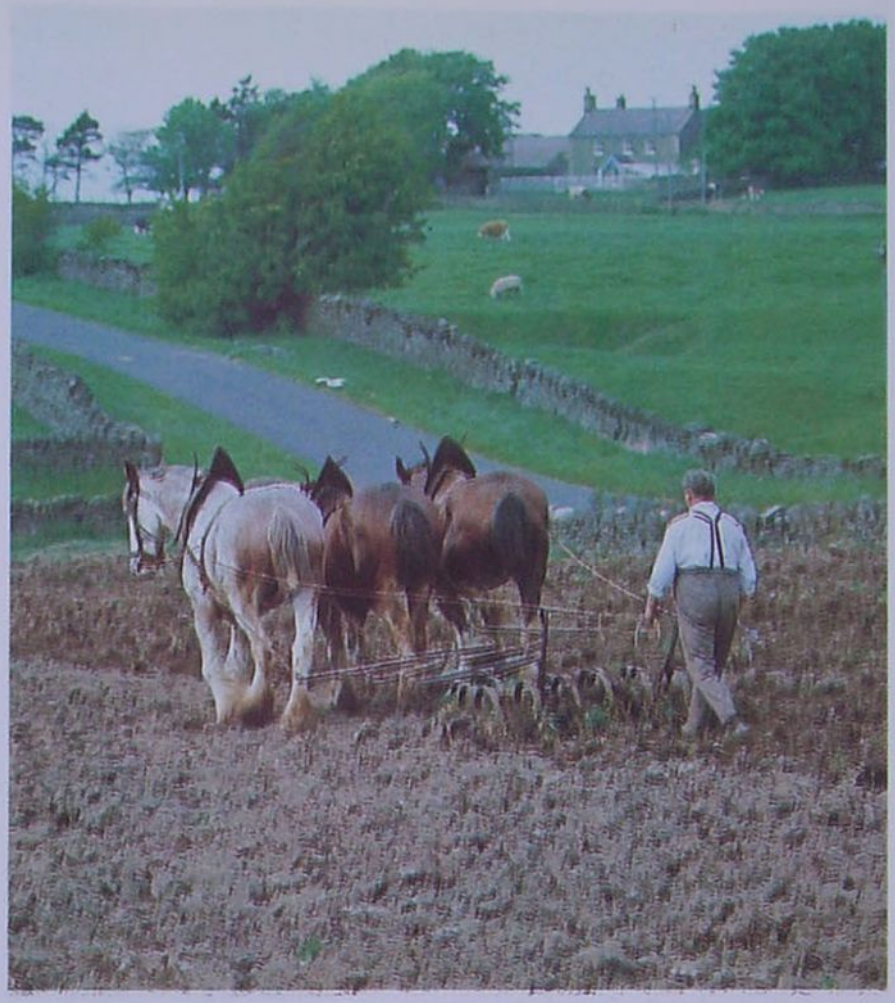


Above: A sessile rotifer, *Collotheca*, attached to a green alga, captures a floating piece of detritus with its fan of cilia. You can see the full length of the cilia more clearly in the drawing immediately above, which also shows the mucus tube surrounding the other end of the animal. Including its cilia, *Collotheca* is a quarter of a millimetre long–no bigger than the dot on a letter i in this caption.

Dormant survival Bdelloid rotifers, extraordinary as it may seem, lack males entirely. They do not, therefore, produce resting-eggs like other types of rotifer, but because they still need to survive desiccation the adults themselves can pass into a state of suspended animation that allows them to survive dry conditions–for many years if necessary. Although remaining permeable to water and gases, the animal slows down its rate of metabolism to an extent that defies measurement.

FARMING SINCE THE SAXONS

Over the last thousand years British agriculture has undergone disasters and changes which have propelled it into the modern era.



At some time during the middle Saxon period –the era of Alfred the Great and the Viking invasions–an extraordinary transformation began to overtake much of lowland Britain. By degrees the arable land, hitherto enclosed into small rectangular fields, was completely reorganised into parishes consisting of two or three huge open fields, sub-divided into long, narrow unenclosed strips arranged in groups called furlongs. All the farmsteads were concentrated at the centre of the parish, and each farmer held at least one strip in each furlong. He also had grazing rights on any common pasture within the parish boundary, and carefully defined rights to cut wood and run pigs in any woodlands. The whole complex arrangement was administered by a parish council–the manor court.

Open fields The origins of this open-field system are obscure, but surviving medieval documents do indicate how it worked. Every farmer had to fit his crops into a cycle laid down for each of the main fields. In the early period many parishes had two such fields and the cycle was simple: each year one field was cropped while the other was allowed to recuperate, and the following year their roles were reversed. The recuperation period, or fallow, involved grazing by stock and repeated cultivation to destroy weeds, and it was essential that each of the unfenced strips within the field was cleared of crops by the time the animals were turned in.

In time the two-field arrangement was superseded by a three-field system which incorporated the principle of crop-rotation. In its basic form this involves sowing successive crops that have different requirements, thereby making the most of available fertility. The advantage of such a sequence is that the field can be used for longer before the soil needs a rest. The classic medieval sequence was: winter corn (autumn-sown wheat), a short 'winter fallow' for weed clearance followed by spring corn (barley, peas or beans), and a year-long fallow. In any year one of the three fields would be under the winter crop, one would bear the spring crop, and one would be fallow and provide rather poor supplementary grazing for the village

Above: Spring cultivation in Hexham, Northumberland, before planting the crops.

Opposite page: Sheaves of wheat drying in the sun. The straw was used as winter bedding for livestock.

Right: The Longhorn was singled out by Robert Bakewell in the 18th century for the first intensive cattle improvement schemes.

Below: A medieval tradition– pigs foraging for acorns in the New Forest.

Above: A typical 18th century enclosed landscape that still survives today. The relatively small fields enclosed by trees and hedges encourage all kinds of wildlife, as well as making the landscape look interesting and attractive.

animals.

By the 12th century the open field villages had come under the control of feudal lords who extracted rent in the form of land, labour and farm produce. The records of these transactions suggest that yields were very low –suspiciously low, in fact. It seems likely that the yield figures were falsified as a form of tax evasion. Nevertheless, it is obvious that any system which leaves a third of the land lying more or less idle each year cannot be very efficient, and to improve the output the system had to change.

Disaster and change During the 14th century Britain was afflicted by a series of disasters including the Black Death, an epidemic which may have wiped out half the population. The effect on agriculture was profound. The shortage of labour encouraged farmworkers to sell their services to the highest bidder; with the money earned they could pay cash rent for their holdings, so freeing themselves from their feudal obligations and encouraging an independent outlook. At the same time there was a switch from labour-intensive arable farming to sheep and cattle. By the end of the 15th century the whole edifice of open-field agriculture was collapsing in the face of private enterprise.

The immediate effect was a vast increase in the area of grassland. In some places whole parishes were grassed down for sheep farming by powerful landlords, while at the other end of the scale the small tenant farmers were exchanging and enclosing strips to form small pastures. In time the unenterprising were squeezed out to become landless farm labourers or industrial workers, while their former neighbours divided the big open fields into smaller, hedged enclosures. This process continued right through the 16th, 17th and 18th centuries until the area left under open-field agriculture was reduced to a few isolated parishes. One of these, Laxton in Nottinghamshire, still remains unenclosed, a celebrated survival of a lost landscape.

Throughout this period Britain was developing as an industrial nation, and there was a general drift from the land into the growing towns. With more urban mouths to feed, the domestic market for agricultural produce became increasingly lucrative, encouraging farmers to plough up their pastures for arable. And since they were no longer constrained to fall in with a village system, there was every incentive to experiment with new crops and techniques.

Improved productivity One of the first ideas to be adopted was the ley system, which involved alternate cropping of the land with arable and grass. During the grass phase the field was used to pasture animals, which manured the land in readiness for the next crop. This technique is still widely employed today.

A variation of this idea was to sow arable crops, such as turnips and swedes, specifically for the animals to eat. The effect on the land was similar, but the animals grew fatter. Sheep normally grazed the crop directly off the field, confined in fields made of wattle hurdles and moved each day to a new area. Cattle, being heavier and more likely to compact the soil, were generally confined in yards on the farmstead; the food was manually harvested and carried to them, and the manure was amassed in a heap ready to be spread on the land before ploughing.

In this way a mixed farming system developed, in which a yard full of cattle or a fold of sheep was regarded as a manure factory. There was nothing essentially new in this, but during the 18th century it became an

Below: June, and the grass is being cut for silage to feed animals in winter. Dairy farmers in particular rely on silage for winter feeding.

obsession. New farmsteads were designed around the stockyard and its muckheap, and fodder crops were partly assessed on the quality of the manure they produced. Naturally the stock prospered, and in due course livestock enthusiasts began controlled breeding programmes to improve the rate at which their animals converted all this food into meat and milk. The results were the first of the modern high-performance farm animals.

The root of the system was the turnip, an awkward crop easily smothered by weeds. In the early 18th century Jethro Tull, a Berkshire farmer, devised a system of planting turnips in rows which enabled them to be weeded efficiently by a horse-drawn hoe. Tull was justly proud of his 'horse hoeing husbandry', and published his results. One of those who took up the idea was Viscount 'Turnip' Townshend of Rainham in Norfolk who, among others, applied it in a novel way.

Instead of sowing the turnips in clean land he sowed them after a cereal crop, in a weed-infested field which would normally be allowed to lie fallow for a year. Hoeing between the rows, however, ripped out the weeds and made the fallow unnecessary. A new four-year rotation was developed, known as the Norfolk Four-course: spring corn (such as barley), grass, winter wheat, and turnips. It was one of the many innovations which dramatically increased farm productivity during what is now called the Agricultural Revolution.

The horse-hoe and seed drill were the first of many mechanised implements which began to appear from farm workshops, village smithies and eventually from urban factories. By the 1860s the big landowners were erecting mechanised farmsteads incorporating threshers, mills, turnip choppers and even light railway systems, all powered by great stationary steam engines.

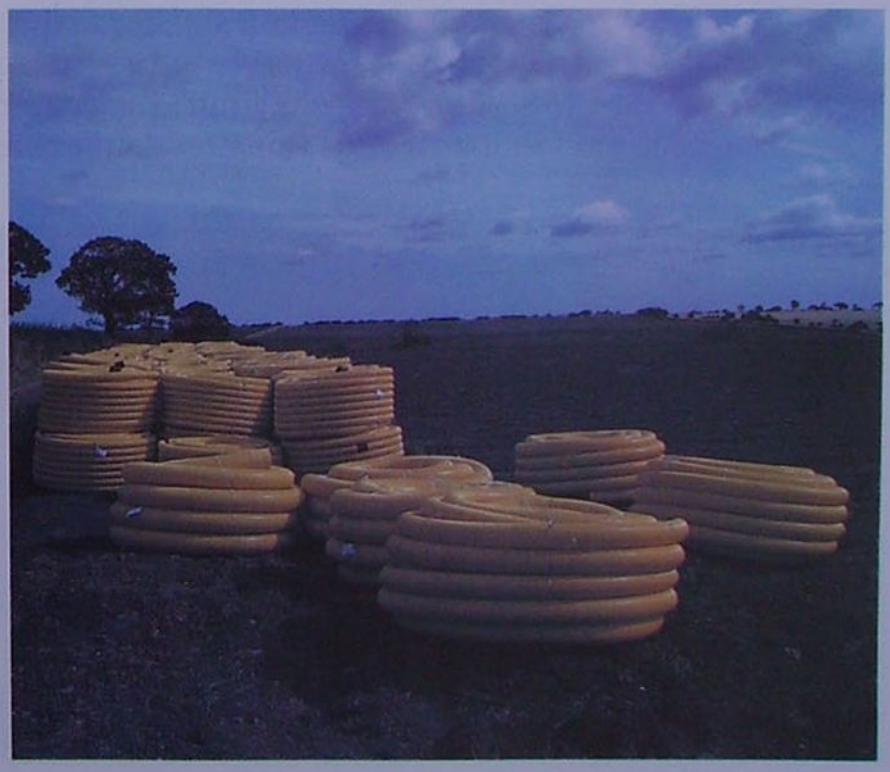
Decline then revival These 'model farms' were the final flourish of an agricultural boom which had lasted for some three centuries. Built on the profits of overpriced food in an era of urban poverty, they were rendered completely uneconomic by the cheap grain and frozen beef which began to flood in from Australia and the Americas from about 1870 onwards. The bottom dropped out of the market, and between 1875 and 1884 the wheat acreage fell by one million acres. The land reverted to pasture, and the farmers fell back on milk as the only produce immune from foreign competition. Except for a short interval during the 1914-18 war, the slump lasted for nearly 70 years.

The revival of British farming began with the outbreak of World War II. The government called for a huge increase in domestic food production, and encouraged the development of efficient farm machinery, artificial fertilisers, weedkillers and pesticides. Within a few years output had doubled, and

Above: Today's high guaranteed grain prices encourage farmers to plough up marginal land and areas of thin chalkland soil such as the Hampshire Downs, shown here. The faint terraces are probably the remains of a ploughed-out medieval strip system.

Britain had undergone yet another agricultural revolution. By the 1950s horses had been superseded by tractors, and the old reaping machines developed in the 19th century were giving way to combine harvesters. Whole new cropping patterns were devised to take advantage of the new chemicals, and by the late 1960s many farmers had abandoned crop rotations altogether. Protected from the uncertainties of the free market by guaranteed prices, the farmers began to specialise, investing heavily in the sophisticated technology of mass production. Agriculture had once again become big business. It still is. Its future under the EEC Common Agricultural Policy remains the subject of fierce debate.

Below: Some of the technology of modern agriculture: drainage pipes ready for laying in the soil.



Above: Starfishes starting to swarm on a mussel bed in the North Sea–these are *Asterias rubens*. The white lines on the rock resemble pavement cracks, but this is a natural substrate.

STUDYING THE WAYS OF STARFISHES

Starfishes crawl at a steady pace across the sea-bed, scenting and tracking down prey animals in a sinister fashion. Their activities are fascinating to observe, but there is also a practical reason to study their behaviour: they can devastate oyster beds, and in man's view this brands them as pests.

Below: A solitary *Asterias rubens* sets off to feed. One ray detects a nearby mussel bed and takes the lead; the other rays are about to begin moving in the same direction.

Starfishes belong with the sea-urchins, sea-cucumbers, brittle stars and feather stars to a group of animals known as echinoderms. To understand their behaviour one has to appreciate that there are radical differences which separate echinoderms from other animals. An echinoderm has no head, nor does it possess a centralised brain. It lacks eyes, although the tips of the 'arms' or rays of starfishes have light receptors known as optic cushions, that form no image but simply detect light. The form of its skeleton differs from that of almost any other animal group. An echinoderm also possesses a unique locomotory system of tube-feet.

How starfishes walk A starfish's body consists of a number of limbs called rays, arranged round a central mouth. The mouth is

surrounded by a nerve ring, from which nerves run off into each ray. Starfishes often have five rays, though *Crossaster papposus* usually has from eight to 13 and *Luidia ciliaris* has seven. The rays do not walk as legs do, but they play an important part in locomotion because they bear the numerous tube-feet on their undersides, and these walk by taking tiny steps, each in the same direction. The tube-feet are arranged in two rows of pairs, with a groove between the rows leading along the ray from the tip to the animal's mouth at the centre of the underside. They are driven by their own muscles and also by the fluid pressure from within the animal.

Starfishes crawl at a slow, steady pace– *Asterias*, for example, can cover several centimetres in a minute. Any of the rays is capable of taking the lead, and as a direction becomes established the tube-feet on all the other rays begin stepping and help propel the animal in the same direction. If accidentally overturned, starfishes have a 'righting response': one of the rays turns over at its tip until the tube feet gain a purchase, and then gradually pull the rest of the animal back into an upright position.

Starfishes have a well-developed sense of smell, enabling them to detect the presence of food or enemies. *Asterias rubens*, for example, can sense from a distance many animals such as oysters, common mussels or scallops, all of which it eats. *Crossaster papposus* does not have such discriminatory powers at a distance, but when in contact with another animal it can make the distinctions necessary for its own survival. When it touches another member of its own species, for example, it sets off in the opposite direction, but when it touches *Asterias rubens* it attacks and eats it.

Feeding behaviour Starfishes are generally carnivorous, and are in fact specialised and efficient killers, capable of interesting behaviour, for they have exploited one particular evolutionary avenue to an advanced degree. Their bodies are just the right shape to wrap round a mollusc or part of another starfish, holding the mouth in direct contact with the victim.

Bivalves are very suitable prey animals: they cannot move about very much, and while their hard shells protect them from many small predators, the starfish can clamber on to the shell and attach some of its suckered tube-feet to each valve. It then begins to pull them open. This steady tension tires out the adductor muscles that hold the shells shut, allowing the attacking starfish to prize them slightly apart. Alternatively, the bivalve may need to open its shells deliberately for its own physiological requirements. Either way, a slight gape is all the starfish needs to insinuate the fine folds of its stomach, which it turns inside out through its mouth and into the shell of the bivalve. Once this is in contact with the live tissue of the victim, digestion begins and the prey dies. When digestion is complete, a well-cleaned empty shell is all that remains and the starfish withdraws its stomach folds and makes off.

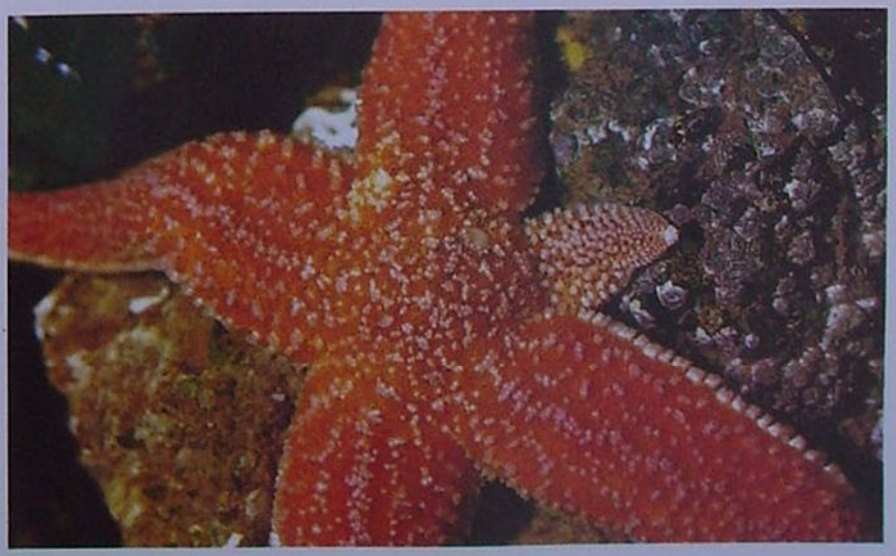
Starfish swarms At certain times some kinds of starfish become strongly gregarious and appear in swarms, often of over 50 and sometimes several thousand strong. There is good reason for investigating this swarming behaviour, for some starfishes can devastate shellfish beds. It is because of this economic significance, therefore, that the study of starfish behaviour has become a scientific priority.

Starfishes that behave in this way all belong to species that prey on animals which sometimes occur in great abundance, such as mussels in beds or corals on reefs. Attracted to the plentiful prey, the starfishes switch from a dispersed, solitary life to a concentrated, gregarious one. *Asterias rubens* abandons its normal tendency to seek dark places if, as often happens, the mussel bed where a swarm develops is in shallow, well-lit water.

Studies with *Asterias rubens* give rise to an

Above: The common sunstar (*Crossaster papposus*) usually has between eight and 13 rays, but the one shown here has 14.

Below: A specimen of *Stichastrella rosea* regrows a lost ray. If damaged in an attack by a predator such as a bird or a fish, a starfish can usually regenerate lost rays. This differs from the regeneration of limbs by crabs or lobsters, which have specially fragile places in their limbs where the breakage occurs and heals rapidly. Virtually any piece of a starfish ray can be regrown if lost, but if the nerve ring surrounding the mouth is damaged this may prove fatal. The nervous system seems to play an important role in regeneration.



interesting conclusion. One feeding individual produces a chemical effluent that repels neighbouring starfishes of the same species until, after a certain amount of exposure to the effluent, starfishes begin to find it attractive. This change in response, from repulsion to attraction, results in a change in the behaviour of the starfishes and, in conditions of plentiful food, leads to the formation of swarms.

How starfishes breed Starfishes do not need to mate, for fertilisation can be carried out at a distance. The sexes are separate in almost all species–males simply release sperm to be carried away on sea currents, and females similarly release eggs. This process is known as spawning, and in British waters it typically occurs in May and June. Fertilisation then takes place by chance encounters of eggs and sperms, after which the egg quickly develops and hatches into a microscopic floating larva.

The larva develops and grows, until it metamorphoses into a very small starfish only a millimetre or two across, which is known as a juvenile. A year after hatching it may be, say, 10cm (4in) across, but it can grow more rapidly and the largest *Asterias* starfishes in British waters are around 50cm (20in) across. Such magnificent specimens may be seen on the west coast of Britain from the Channel Islands north to Scotland where the warm waters of the North Atlantic Drift (the so-called Gulf Stream) provide good conditions for growth.

Above: An *Asterias rubens* feeding: its hunched stance resembles the spawning posture of *Marthasterias glacialis* (right). An underside view of *Asterias* with the remains of its prey is seen below.

British starfishes generally do not swarm to breed, though feeding aggregations may be at an advantage for breeding because of their close proximity.

Burrowing starfishes While most starfishes live on rocks, some are sand dwellers and these can be efficient burrowers. Burrowing enables them to escape detection by predators, as well as to hunt for molluscs that lie in the sand. These starfishes differ in the development of their tube-feet from other starfishes. *Astropecten irregularis* and *Luidia ciliaris* are examples: unlike the rest, they have no suckers on their tube-feet, for these are not useful in their shifting habitat. Individual tube-feet can lift sand particles up on to the back of the starfish, which thus gradually burrows down as more sand is lifted upwards. These tube-feet are also well adapted for walking over the surface of the sand. Burrowing starfishes also eat various surface-dwelling animals, emerging from the sand in order to capture them. In evolutionary terms these starfishes are relatively primitive.

WATCHING BIRDS IN THE GARDEN

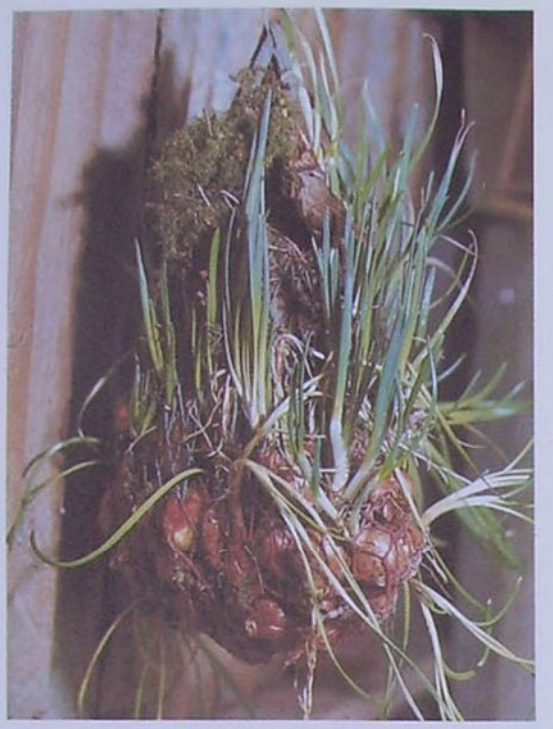
Garden birdwatching provides never-ending interest and enjoyment, and has a unique practical aspect as well: helping to provide birds with the necessities of life such as food, water and shelter is a fascinating challenge to the inventive naturalist.

The garden is a place where the birdwatcher enjoys a specially close relationship with bird life. Nowhere else can he or she exercise such control over the birds' environment at all times of year, perhaps even for an indefinite number of years. In many cases this leads to a surprising level of personal acquaintance with individual birds, and the ability to recognise new birds as soon as they make their first appearance in the garden.

Ecology of gardens Although they are man-made, gardens are in effect extensions of woodland and from the point of view of birds they have many of the best features of this habitat. Such features are a rich structure of different micro-habitats – well-turned soil,

Above: The village of Merton in Oxfordshire, photographed from an aircraft. Wherever there are vegetable patches and fruit bushes, there you will find birds: in the large garden at the centre of the picture, painstakingly covered fruit bushes testify to the massive number of them present in this village.

Right: Hang a bag of peanuts in your garden, and you may receive a visit from a nuthatch like this one.



Left: Wrens, though shy of humans, find nest sites in quiet places such as this unfrequented garden shed. The nest is hidden among sprouted onions.

Below: House sparrows, a female blackbird and starlings feeding on garden scraps: there is always a wealth of interest and enjoyment to be had from seeing just which bird eats what and which species are dominant. It is also fascinating to observe how they achieve their dominance –whether by aggressive treatment of rivals or by speed and skill in seizing a morsel first.

Bottom: The kestrel is the most common bird of prey in the garden.

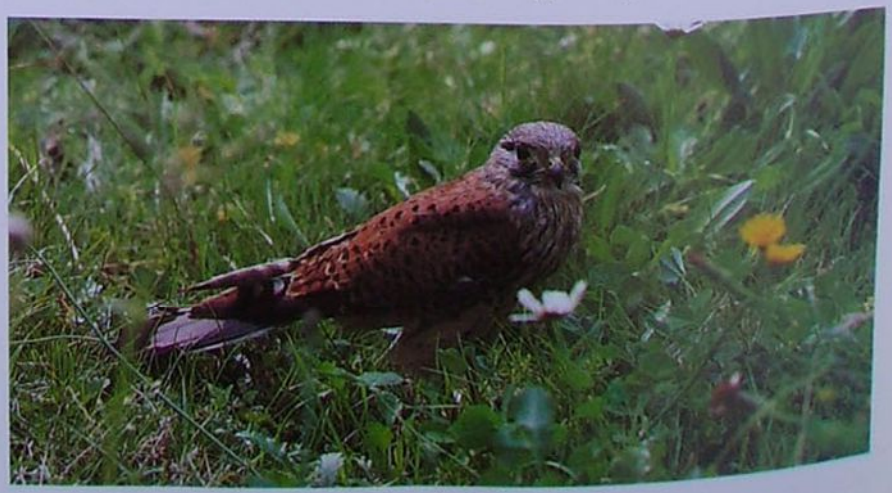
weeds, turf, annual and perennial herbaceous plants, shrubs and tall trees–offering much in the way of food, roosting places and nest sites. An additional advantage is the plentiful open space in and between gardens. This is vital to so many birds for such purposes as seeing predators from a good distance, and for performing display and feeding flights. The importance of open space is reflected in the strong preference birds show for the woodland edge as a habitat, rather than the interior of a wood.

Planting for birds For the birdwatcher who wishes to select the most appropriate trees, shrubs or herbaceous plants to put in a garden, many interesting possibilities arise. Gardening books list some 20 species, varieties and hybrids of cotoneaster, all producing berries. These, and the many forms of crab apples, hold their fruit until late in winter when many birds experience a shortage of food in the wild; such trees therefore make an attractive garden, and simultaneously provide a range of birds to complement the gardener's skills.

Some areas can even be left rough, to allow grasses and weeds to develop, the seeds of which provide food for finches and other seed-eaters. One weed that provides fascinating birdwatching is teasel, which in fact is good for goldfinches and flower-arrangers alike!

Building for birds Bird tables, hanging coconuts, peanut bags and many other ingenious devices provide plentiful interesting birdwatching in winter and early spring. Feeding should, however, be discontinued during the summer as it has been found that many of the foods commonly offered are positively harmful to the young chicks. Instead, the garden birdwatcher would do better to concentrate on putting up artificial nest sites to bring a wide variety of birds into the garden. For tits, small boxes are made with a single small entrance hole, while other small nestboxes, with an open front, are attractive to robins, spotted flycatchers and many other small birds. A more adventurous exploit is to set up a nestbox for kestrels in the garden: these are somewhat larger, with an open front, and can be mounted on poles for they need no foliage for cover. The British Trust for Ornithology publishes a booklet on nestbox schemes with details of construction, and also lists the dozens of kinds of birds that can be attracted by nestboxing. Planning a garden nestbox scheme, however small, becomes a fascinating exercise itself if carried out with advice from an experienced ornithologist.

While nestboxes provide protection from above in the form of a roof, they may need additional protection from below, mainly to prevent squirrels or cats from climbing up to raid the nest. This is achieved by making an inverted funnel on the trunk of the tree (or on the pole), supporting the nest box. A more



attractive alternative is to make this funnel shape out of sprays of the prickliest gorse available.

Water and shelter Towns and villages cannot exist without water: the most conspicuous sources are rivers, canals, reservoirs and ornamental lakes. But probably of more material help to a greater number of birds are the innumerable garden ponds and drinking troughs specially placed for them. In addition, rainwater gutters provide yet another drinking facility.

Just as their rural cousins do, the birds of our gardens need to roost overnight: they need both concealment from predators and shelter from the wind, rain and snow. Shrubby vegetation and cavities in buildings accommodate the majority of those that roost singly or in small groups. Nestboxes become valuable in winter for several species: in one case over 60 wrens were seen to emerge from the single entrance hole of a nestbox designed for tits, after a cold night spent huddled together for warmth inside. Communal roosters, such as blackbirds in winter, make good use of large shrubberies such as rhododendron clumps.

Birds as vandals It has to be admitted that not all of the birds that are tempted into gardens by the provision of food or protected nest sites may be wholly acceptable to man. House sparrows damage flowering plants–not only yellow crocuses but young chrysanthemums, carnations and others as well–although they destroy the blossoms only to reach the nectar inside, not as wanton vandalism. Wood pigeons are notorious as pests of brassica crops, be they on the farm or in garden vegetable patches. And there is a subtle contrast between two doorstep visitors: most householders will tolerate the attacks on milk bottle tops by tits, and the loss of the upper layers of cream, in return for the opportunity to watch and enjoy their agility when afterwards feeding among the twigs of trees or else on hanging nuts. Less acceptable are the magpies: arch egg-predators, in some areas they have learnt to associate the sight of a milk float on its daily round with cartons of hen's eggs delivered to the doorstep. In these areas it is now necessary not only to protect the milk from tits by covering it with upturned beakers: the eggs must be placed under cover too.

Above: An attractive nestbox, easily made by hollowing a log and drilling an entrance hole. Its occupant is a coal tit.

Below: A song thrush on a cotoneaster bush. Native plants can be equally attractive to birds: pussy willow, hawthorn, holly, hornbeam, beech, berry-producing privets and berberis are all useful. A conifer gives good cover for secretive birds, while on the wall, attractive plants include ivy and the introduced pyracantha.

Opportunists at large The magpie, the collared dove and the starling display opportunism, or the tendency to exploit new resources as they become available, rather than being restricted always to the same features occurring naturally as part of their habitat. The opportunism of these three birds lies in frequenting human habitations for the sake of fresh food, spilt grains and food leftovers. The recently introduced ring-necked parakeet from India manages to survive in our temperate climate by opportunist raids on almost any species of garden fruit tree or seedhead in summer, and by learning to visit bird tables in winter.

Attacking the many smaller birds of the garden in an opportunist or 'take-what-you-find' strategy are a number of birds of prey. The kestrel is among the commonest, but in the west and north of Britain the sparrowhawk is becoming a more frequent, if dashingly brief, garden visitor. At night, the tawny owl proclaims its presence with quavering hoots across the suburbs. Though essentially a woodland bird, it has discovered that good-sized gardens or stretches of many small back gardens with tall trees and open spaces offer acceptable habitats. The tawny owl does not appear to object to the monotony of a diet of mice and sparrows.

WASPS: SOCIAL OR SOLITARY

In the British Isles we have over 250 species of true wasp. Most lead solitary lives and rely upon venom in their sting to immobilise prey.

Above: The social wasps overwinter as hibernating queens and begin afresh every spring with new nests. This queen German wasp (*Vespula germanica*) is feeding on an overripe plum in autumn to build up fat before hibernation. In the winter months queens can be found clinging to curtains with their jaws or hiding away in attics.

Below: Female spider-hunting wasps such as this *Anoplius infuscatus* seek and attack ground dwelling spiders. The spider is dragged to a patch of soft earth or sand where the wasp deposits her prey and begins to excavate a nest, but she has to be careful: her unattended prey may be stolen by another female wasp.

Wasps, along with bees, ants, sawflies and a whole host of other parasitic insects, belong to the order Hymenoptera. With the exception of sawflies they all have a very narrow connection between their abdomen and thorax often known as a 'wasp-waist'. Many hymenopterans are commonly called wasps but are not true wasps–ichneumon 'wasps' are an example of such insects. The true wasps are characterised by two features–their ovipositor is modified to form a sting and they feed their young on captured prey, either insects or spiders. The adult true wasps are usually black and yellow or black and red and feed upon nectar.

Meat eaters As a group the wasps show a remarkable variety of life styles, each evolved to maximise the survival of that particular species. Each species of wasp specialises in certain kinds of prey, often flies and beetles, selecting what may seem to us to be uncommon insects, which they are nevertheless able to find with uncanny regularity. The stings of these wasps inject a venom that paralyses insect prey but which has little effect upon vertebrates.

The true wasps can be split into two broad categories: the solitary wasps, which make and stock a dozen or so nest cells in a season; and the social wasps, which are highly organised with a queen, workers and a large nest containing thousands of cells.

Solitary wasps The very simplest wasps seek out their prey, often in soil, then immobilise it with a sting before laying an egg on it. In this way they show a close resemblance to the parasitic ichneumon 'wasps'. All other solitary wasps find their prey, sting it and then transfer it to a nest where it is stored in a live, but paralysed, state for the young wasp grubs to feed on.

Prey is carried back to the nest in a variety of ways. In the simplest method the wasp grasps a leg in its jaws and drags the prey backwards for some distance. All other wasps use their legs in one way or another to hold the prey beneath their bodies as they fly or walk. The social wasps tend to hold their prey in jaws and front legs, while some solitary wasps fly with their prey impaled on their stings.

Above: The hexagonal combs inside the wasp nest are made from chewed-up wood and each is used to rear a wasp grub. Eggs, grubs and emerging adult wasps are seen in this piece of comb taken from a nest.

Left: The velvet ant, *Mutilla europaea*–actually a wasp–has a wingless female and a winged male (seen here). The female enters bumble bee nests and stings fully grown grubs before laying her eggs on them.

Below: In the British Isles we have two species of sand wasp (*Ammophila*), both of which catch and immobilise caterpillars before dragging them off to replenish their brood cells.

Although the adult wasps do not eat their prey–they use nectar as a more readily available source of energy for their active lives –it is not uncommon for them to chew at their prey and drink their body juices. Some species which attack bees often drink the contents of the bees' stomach.

In common with social wasps, solitary wasps lay their eggs in specially constructed cells. In the case of solitary wasps these cells are built inside shafts dug usually in soil, though a few species prefer to use holes in wood or walls. Once the shaft has been dug the mother wasp begins to lay her eggs inside the cells. In the innermost cells–those at the back of the shaft–she lays fertilised eggs that will hatch into females, while at the front of the shaft she lays unfertilised, male-producing eggs. But how the mother knows whether to lay fertilised or unfertilised eggs is a mystery The purpose of this separation of the sexes is to encourage males to emerge early in the following year (since they are at the front of the shaft they naturally emerge first), and it also helps to prevent brother/sister matings, which would be undesirable.

As the mother wasp lays her egg in each cell she adds some prey items to provide food for the emerging grub, the male grubs receiving less food than the females since the females will grow to become larger.

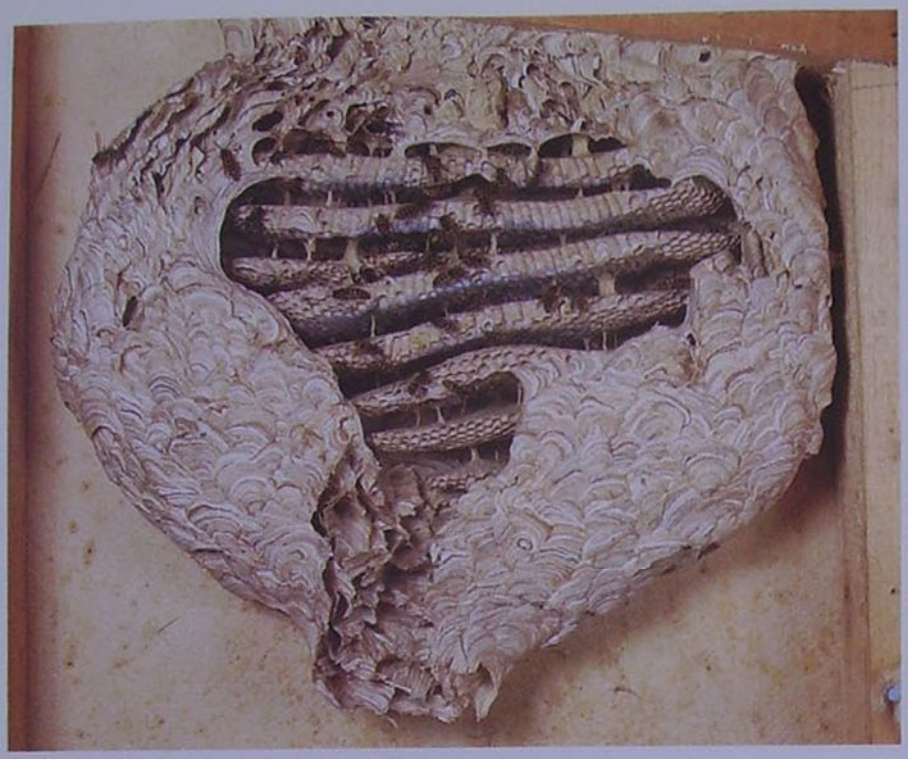
In practically all solitary wasps the mother wasp never sees her offspring, as she dies at the onset of autumn while the now mature grubs pass the winter safe inside their cells.

False parasites Wasps most closely related to the ichneumons include species of *Tiphia*–black wasps which burrow into the soil in search of larvae of chafer beetles on which they lay their eggs. The beetle larva usually recovers after the sting and continues feeding until it eventually succumbs to the feeding of the *Tiphia* larva.

The wingless females of the wasp *Methoca ichneumonoides* specialises in attacking the fierce larvae of the tiger beetle in their burrows. The wasp locates the tiger beetle burrow and immobilises the larva with a sting before laying an egg on it. Once the wasp has immobilised the beetle larva and laid an egg, it fills in the beetle burrow with soil.

Nest provisioners All other solitary wasps prepare a nest for their prey, either before or after catching and stinging it. The spider-hunting wasps first catch a spider before dragging it to a suitable site for excavating a burrow while others dig the burrow first and then seek prey to provision it. Such species have to memorise the exact position of their burrows and use bushes, stones and debris on the ground as clues to relocating them.

Species of *Cerceris* burrow with their legs, and eject soil with their hard 'tail' acting as a ram. There are two common species of *Cerceris* on heaths; one catches weevils and the other preys on bees of the genera *Halictus*



and *Andrena*. They provision each cell with several items of prey before an egg is laid and the next cell started. The position of the egg is important because the young grub must be able to find food straight away. With hard bodied weevils the egg is usually placed in a soft part such as where the leg joins the body.

Wasps of the genus *Crabro* often make their nests in decaying wood, each nest consisting of a row of individual cells stocked with flies.

The red and black sand wasp, *Ammophila pubescens*, differs from other solitary wasps in that the female does not stock the cells and leave them, but maintains two or three single-celled nests in the sand at the same time. She places an immobilised caterpillar in each cell and lays an egg on it before putting a temporary closure of small pebbles over the cell entrance. Every day she removes the plug and inspects each cell to decide whether the larva needs more food and, if necessary, she fetches another caterpillar. The cell is only sealed over pemanently once the female wasp is satisfied that the larvae are fully grown.

Mud nests Potter and mason wasps are more closely related to the social species than preceding examples and build a small nest of clay of mud. The female mason wasp, such as species of *Ancistrocerus*, finds a suitable hole in a wall or in wood, where she provisions a number of cells. Each cell is separated from its neighbour by a mud partition and has an egg laid in it before being provisioned with a dozen or so paralysed caterpillars.

The female potter wasp, *Eumenes coarctatus*, makes flask shaped nests from pellets of mud on low bushes such as heather. Again she lays her egg before storing up to 20 small paralysed caterpillars and eventually sealing the neck of the nest with more mud. The larvae feed quickly and, as with other solitary wasps, remain as fully grown larvae all through the winter to pupate in the spring.

Above: The nests of social wasps are formed either in holes in the ground or in hollow trees, sheds or attics. The large nests of the common wasp (shown here) can be 25cm (10in) in diameter and contain 10,000 cells.

Above right: Common wasps are voracious predators and will attack and kill other insects to feed their grubs. This worker has killed a hoverfly, *Eristalis tenax*, and is biting its head off before carrying away the corpse to the nest.

Below: The digger wasp (*Mellinus arvensis*) is a solitary species that lives in shafts in the sand. These it excavates by backing out of the hole, dragging particles of sand between its head and front legs.

Social predators The social wasps–the hornet (*Vespa crabro*) and the common wasps, *Vespula* species–represent the highest stage in wasp evolution although they are not quite as organised as their relatives, the honey bees.

The queen social wasp emerges from hibernation in spring and seeks a suitable site in which to build a new nest. Her nest is made from chewed wood fragments fashioned to form a globe, inside which combs of cells are suspended. In each cell the queen lays a single egg and when the eggs hatch she supplies them with food in the form of insects such as flies. In a few weeks the grubs grow, pupate and then hatch as adult wasps. These are the subordinate workers which take over the chores of the queen and leave her free to stay in the nest and lay more eggs. Each worker lives for about three weeks and at the height of the season a nest may contain 3000 such workers.

As with honey bees there is a constant exchange of food among the individual wasps and this activity ensures also that the queen is fed. These exchanges seem to contribute to discipline in the colony and regulate the behaviour of the wasps. This is also helped by the presence of the queen, without whom the colony would lose coherence and eventually disintegrate entirely. This naturally occurs in autumn when the old queen dies after rearing new queens for the following year.

Typical wasps

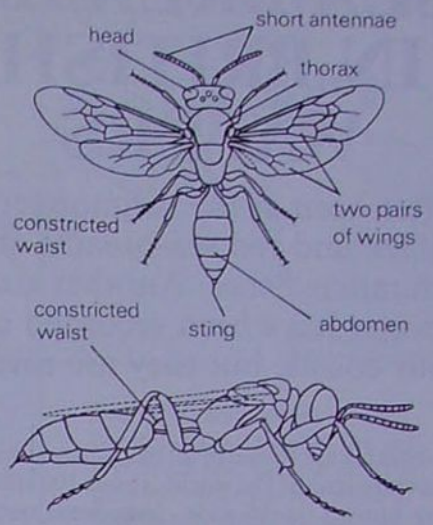
Many wasps have a basic black and yellow pattern but, whatever their colour, most are recognised by their constricted waist and two pairs of wings. Except for the hornet, the species here are twice life-size.

Principal wasp families

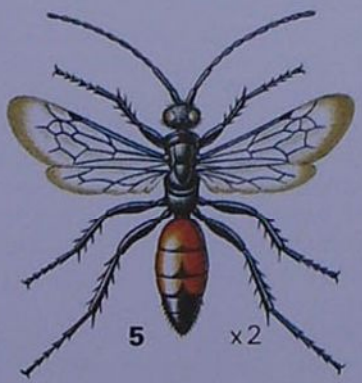
ORDER: HYMENOPTERA

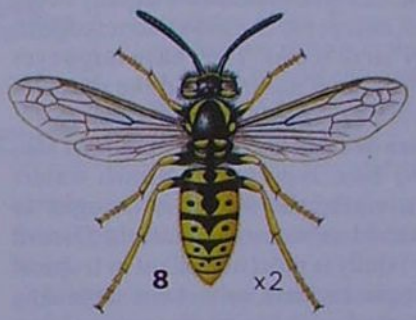
Family	Common name	No. of British species
Chrysididae	Ruby-tail wasps	31
Tiphiidae		4
Mutillidae	Velvet ants	2
Others (4 families)	Solitary wasps	61
Pompilidae	Spider-hunting wasps	41
Eumenidae	Potter and mason wasps	22
Vespidae	Social wasps	7
Sphecidae	Digger wasps	113
	TOTAL	281

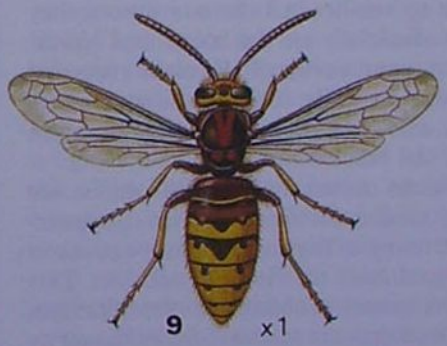
Wasp features



1 *Chrysis ignita*
2 *Myrmosa atra*
3 *Mutilla europaea*
4 *Sapyga quinquepunctata*
5 *Anoplius viaticus*
6 *Ancistrocerus nigricornis*
7 *Eumenes coarctatus*
8 German wasp *Vespula germanica*
9 Hornet *Vespa crabro*
10 *Gorytes tumidus*
11 *Pemphredon lugubris*
12 *Crabro cribrarius*

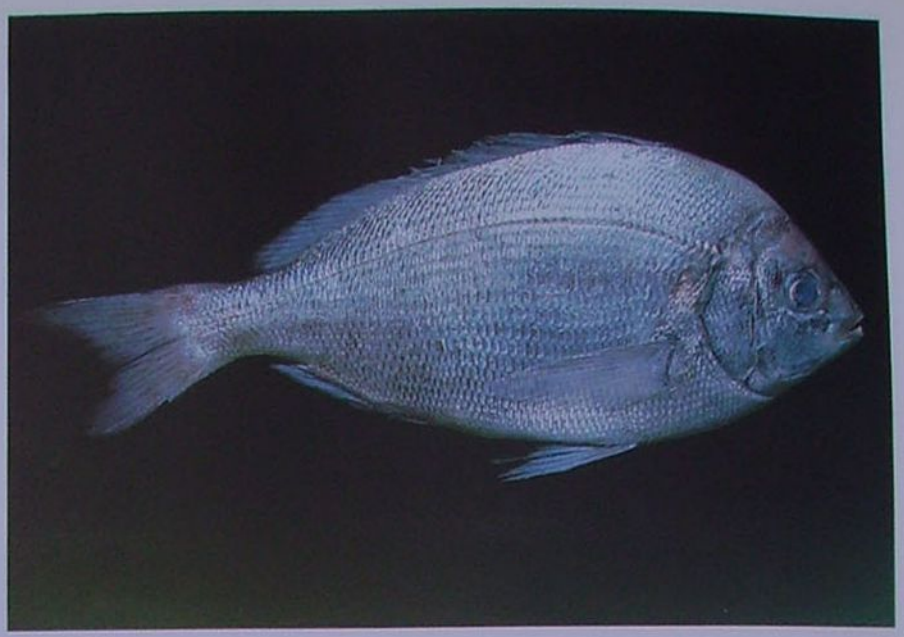






SEA-BREAMS IN BRITISH WATERS

Often seen at the fishmonger's, black and red sea-breams are familiar fishes. Another six species have been recorded on our coasts, but they are rare.



Above: An adult black sea-bream. Britain has a resident population of this species, one of its best-known spawning areas lying off the Sussex coast at 75m (40 fathoms) depth. Unfortunately, selfish anglers over-exploited the stock there, sometimes catching hundreds of fishes on a single outing.

Right: A shoal of saupe–the potential ninth species of sea-bream occurring in our coastal waters. These fishes are very numerous in the Mediterranean, but some do find their way up into the North Sea, and could well be reported one day somewhere off the British or Irish Coasts.

Below: Features common to all sea-breams include a deep body shape and the joining of the two dorsal fins into one continuous fin.

Sea-breams are found in all tropical and warm temperate seas of the world, about 100 species being known world-wide. In general outline they are typical of the bony fishes, while their characteristic features include strong spines in the front of the first dorsal and anal fins, and in the pelvic fins. Sea-breams are usually deep-bodied and, except for the snout, covered with moderately large scales. They have large eyes and relatively large mouths, and the shape of the teeth varies markedly between genera.

British sea-breams Only eight kinds of sea-bream have been reported in British waters although a ninth, the saupe, is thought to occur here and has been caught off the Danish coast. The family is most abundant in tropical and sub-tropical waters, so it is not surprising that our rather cool temperate seas are less attractive to sea-breams. In our waters they are most abundant on the south and south-west coasts, and seven of the eight recorded species are summer migrants from more southern seas: our only resident population is that of the black sea-bream.

Sea-breams occurring in British waters are generally similar in their superficial appearance, and many of them are reddish or pink in colouring, at least on the sides and fins. This sometimes causes problems in identification, and the problems are made worse by the rarity and unfamiliarity of several of the species. One feature that at least helps to sort them into genera is the shape of the teeth, together with the way they are arranged in the jaws.

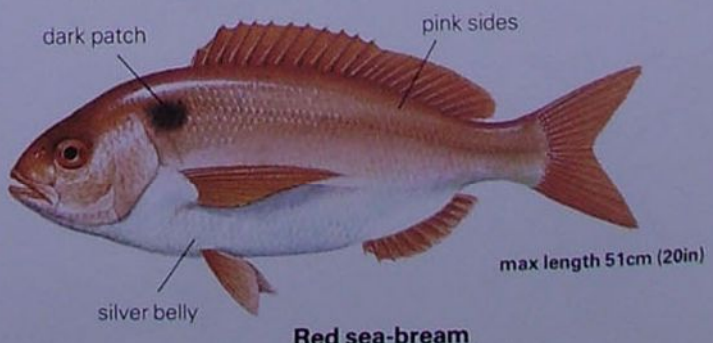
Small, sharp teeth The least specialised teeth are seen in the black sea-bream, which has numerous rows of small sharp teeth in the front and sides of both jaws. Only the teeth of the outer row are enlarged, and then they are about twice the height of the inner teeth. The black sea-bream's food is very varied, for it includes fine algae, encrusting animals from the rocks, small crustaceans and fishes, and clearly its teeth are well adapted to feed on such a general diet.

Flat, interlocking teeth Relatively few sea fishes feed on algae and the black sea-bream relies on them in only a small way. In contrast, another British sea-bream, the bogue, feeds on algae as a major part of its diet. Its teeth show an advanced degree of adaptation to this way of feeding. The incisors are flattened in both jaws, and each of the teeth on the lower jaw has a small sharp point called a cusp, situated on the mid-line, which locks into a notch in the opposite tooth of the upper jaw. These teeth are superbly shaped for grazing on green algae growing on rocks, and on coarse brown seaweed, as well as for removing encrusting growths of sponges, moss animals and eel-grass.

Small molars The red sea-bream has small pointed teeth in the front and sides of the jaws which give way to small, rounded crushing teeth in the rear of the jaw. The pandora and Spanish sea-breams have similar teeth. Each of these three kinds of sea-bream has a very varied diet, consisting mainly of fishes, some squids (in the case of the larger fishes), and larger prawns and crabs. The hard shells of these latter are crushed by the rounded teeth in the jaws.

Large molars Crushing molar teeth in the rear of the jaws are a feature of the gilthead sea-bream and of Couch's sea-bream, and in both they are distinct and button-like. Both eat large quantities of crustaceans and molluscs. The gilthead especially lives in estuaries, which are rich in molluscs, and it feeds heavily

Three British sea-breams



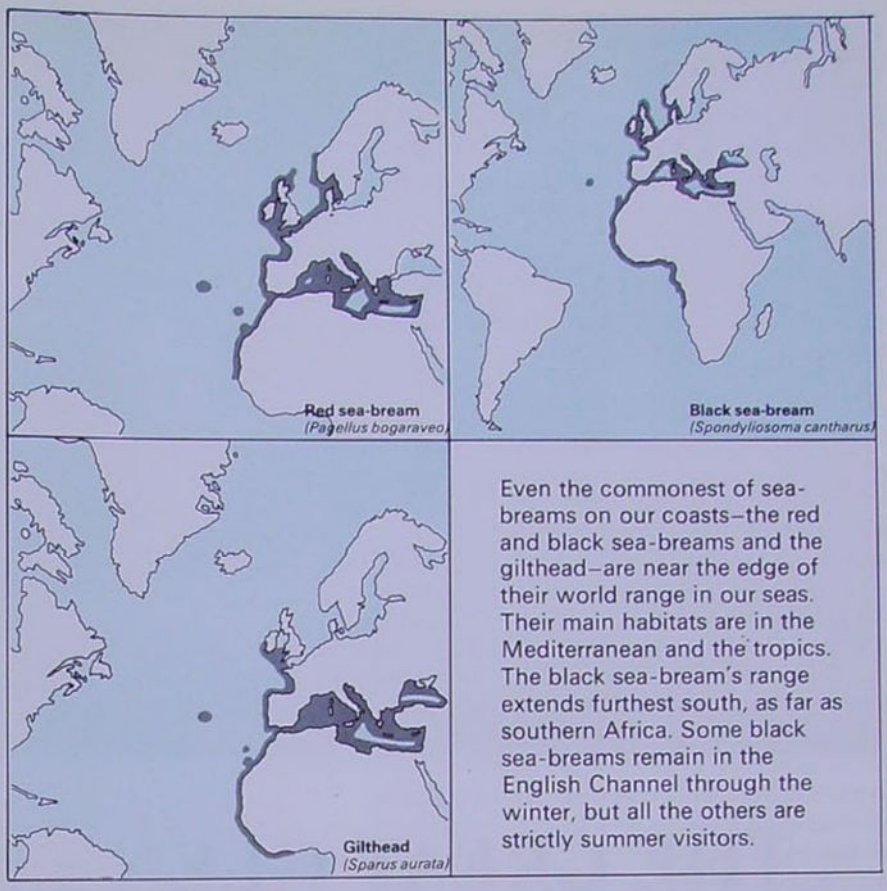
Red sea-bream
(Pagellus bogaraveo)

on cockles, oysters, mussels and other species.

Fangs of a predator The final variation on sea-bream dentition can be seen in the dentex, which has large fangs in the front of the jaws. A large specimen of around 1m (40in) length has front teeth about the size of the canines of a Labrador dog! It feeds almost entirely on fishes, cuttlefishes and squids, and is a very efficient predator.

Two most common species The red sea-bream is probably the most common of the family on our coasts, and is certainly the most widely distributed. It arrives in the summer and is regular in occurrence only on southern and south-western coasts, but large specimens do occur with moderate frequency as far north as Orkney and even on the Rockall bank. Whether their occurrence this far north is part of a regular northward migration during the summer months is not certain; it is at least probable that such northerly sea-breams are vagrants–wanderers that have moved north while the water is warm but are lost to the breeding population. They will probably stay in the cooler northern waters until they are caught by fishing boats or die naturally.

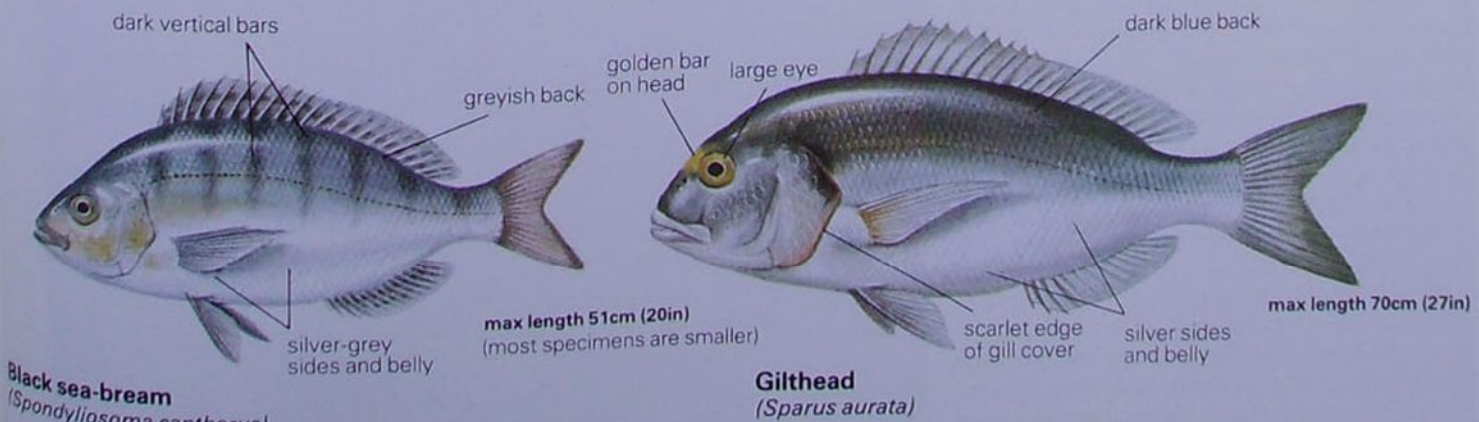
The black sea-bream is almost as abundant on the coasts of southern Britain as the red sea-bream. When young it has faint yellow stripes on its side, but adults are dark, and breeding males become almost black on the head.



Even the commonest of sea-breams on our coasts–the red and black sea-breams and the gilthead–are near the edge of their world range in our seas. Their main habitats are in the Mediterranean and the tropics. The black sea-bream's range extends furthest south, as far as southern Africa. Some black sea-breams remain in the English Channel through the winter, but all the others are strictly summer visitors.

Unlike most other sea-breams, and indeed most other sea fishes, the black sea-bream lays its eggs in a nest which the male digs in the sea-bed. These nests are usually shallow depressions in the sand, often close to an outcrop of rock or beside a wreck. The male guards the eggs and the young fishes, which tend to live in a tightly packed school for the first weeks of life. The fishes are almost social in the breeding season, hollowing out numerous nests in close proximity to one another; but each male fiercely defends the area surrounding his own nest against any neighbour.

The gilthead This fish comes third in order of abundance; it occurs relatively regularly on the coasts of Devon and Cornwall, and in the Channel Islands.



Black sea-bream
(Spondyliosoma cantharus)

Gilthead
(Sparus aurata)

THE GREAT GLEN OF SCOTLAND

Look on any map of Scotland and one of the most noticeable features you see is the straight diagonal line that divides the Highlands, running from Fort William in the south-west up to Inverness in the north-east. This line is the Great Glen.

For most of its 88km (55 mile) length, the Great Glen is extremely narrow–less than 1.5km (1 mile) wide–with the ground rising steeply on each side to the mountain massifs of the Monadhliath to the south and the north-west Highlands to the north. More than half the length of the glen is occupied by three lochs: Loch Lochy in the south-west, Loch Oich in the middle, and Loch Ness in the north-east. At its highest point the glen is only 45m (150ft) above sea level; consequently it provides a 'through route' between the two halves of Scotland for the dispersal of lowland plants and animals (including man!) while acting as a barrier to high-altitude species.

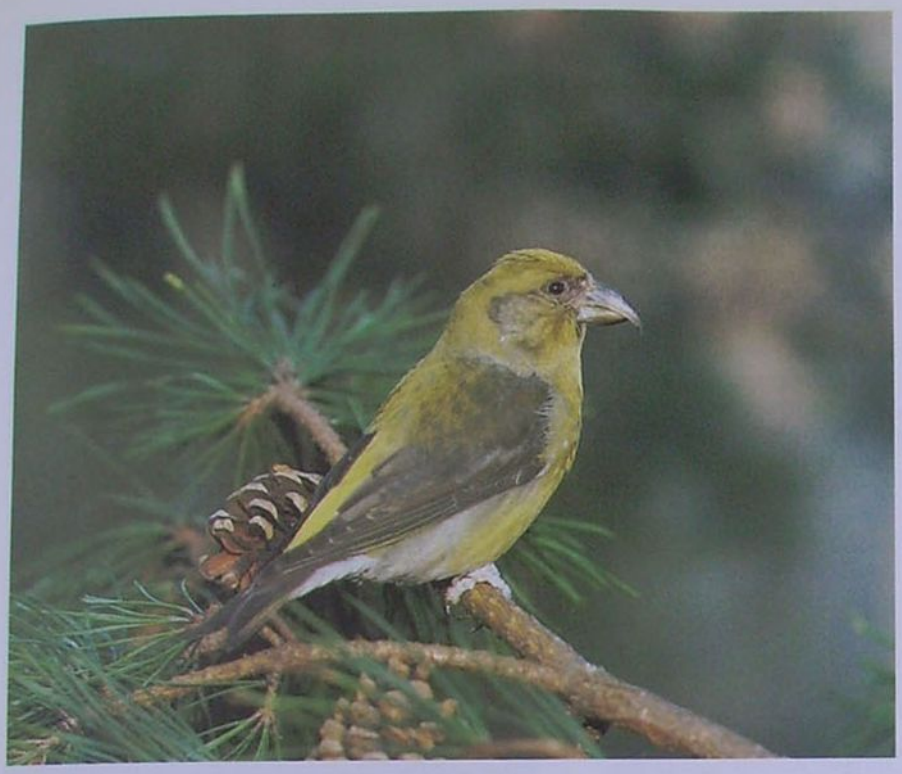
Birth of the glen The Great Glen lies along the line of a major geological fault, and the land on the two sides of the fault has, at some time in the past, moved relative to each other. This can be seen in the rocks on either side of the glen: those on one side are different from those directly opposite. The land mass to the north of the fault is composed of metamorphic rocks of the Moine series, formed during the Precambrian period more than 570 million years ago. These very hard, ancient rocks weather slowly to give poor acidic soils. At the northern end of the glen, from the Moray Firth inland to Drumnadrochit, the Moine rocks are overlain with more recent sedimentary deposits of Old Red Sandstone, laid down between 350 and 390 million years ago. Although acidic in composition, these softer rocks weather more readily and give fertile soils.

On the southern side of the Great Glen Fault the rocks are also predominantly of the Moine series, though in places they are more calcareous than those to the north. There are also deposits of Old Red Sandstone, but they extend further inland–as far as Foyers, which is some 10km (6 miles) south-west of Drumnadrochit. There is also an isolated outcrop on the southern shore of Loch Oich. Two granite intrusions occur along the glen, one on the north side on the shore of Loch Linnhe and the other on the south side at Foyers.

Geologists have attempted to correlate the

Above: The Caledonian Canal leading into Loch Lochy.

Below: Bugle is an important source of nectar for the chequered skipper butterfly, a species unique in Britain to the glen.



different rock exposures on either side of the fault, and thus to determine the direction of movement along the fault and when the major activity occurred. But the results are conflicting and the debate continues. It is currently thought that the Old Red Sandstones could have been deposited after the main movement along the fault had taken place.

The modern glen is very much a creation of the last Ice Age. It shows the classic features of a glaciated valley: a steep-sided U-shaped cross-section; overdeepening where the valley floor, now occupied by lochs, has been gouged out by glaciers; and hanging tributaries where streams show an abrupt increase in gradient where they drop into the glen.

Above: In the woods of native Scots pine and plantations of Sitka spruce the crossbill feeds on the cones, its hooked bill allowing it to extract the seeds inside.

Below left: Melancholy thistle grows beneath the stands of alder.

Below: Pine martens live among the conifers. They are rarely seen, though the number of droppings they leave suggests there is a good-sized population.

Man's influence The twin effects of geology and the coming and going of the Ice Age, along with the present climate of the area, have done much to determine the distribution of the different types of vegetation. But on top of this natural pattern, man and his domestic animals have superimposed their own influence.

In the Highlands, flat land is at a premium and the valley floor of the Great Glen provides one of the few areas suitable for arable cultivation and improved pasture. The size of the farms varies from small crofts to large estates. Land unsuitable for cultivation has long been used for grazing, both by domestic stock (mainly sheep) and red deer. Since the 1920s large areas, particularly the steep sides of the glen, have been given over to Forestry Commission plantations, usually of exotic conifers.

The lochs, too, have not escaped man's attention. The Caledonian Canal, opened in 1822, links the three lochs of Loch Lochy, Loch Oich and Loch Ness, thereby linking the east coast of Scotland to the west.

Four woodlands Around the southern end of the Great Glen and along the northern shore of Loch Linnhe grow woods dominated by sessile oak, the only native species of oak in north and west Britain. Growing on acid soils, these woods have only a limited range of plants in the ground layer, with just a few herbs, such as bluebell, pignut and bugle, present as well as some grasses and mosses. The shrub layer is also sparse, hazel being the commonest species.

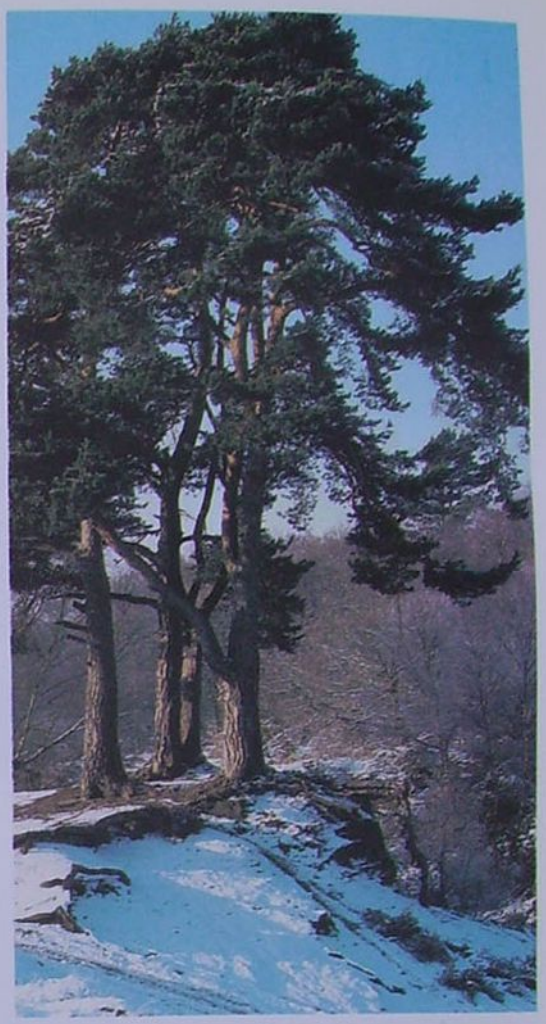
One species unique to this area is the chequered skipper butterfly. Formerly thought to occur only in the East Midlands of England and East Anglia, it was discovered in the southern half of the glen in 1939–it has since become extinct in England. This species

has very precise requirements, needing sheltered but sunny glades in which to fly, wood false-brome grass for its larval foodplant and early-flowering herbs to provide nectar for the adults.

On the cold, north-facing slopes of the tributary glens, such as Moriston, Garry, Mallie and Loy, remnants of Scots pine woodland still occur. Elsewhere the main conifer woods are those planted by the Forestry Commission. Some species of mammals and birds native to pinewoods have been able to move into the maturing forestry plantations–red squirrels and crossbills, for example, which are both capable of feeding on Sitka spruce cones as well as those of Scots pine. Pine martens, too, live in both types of forest, where they prey on small mammals and birds.

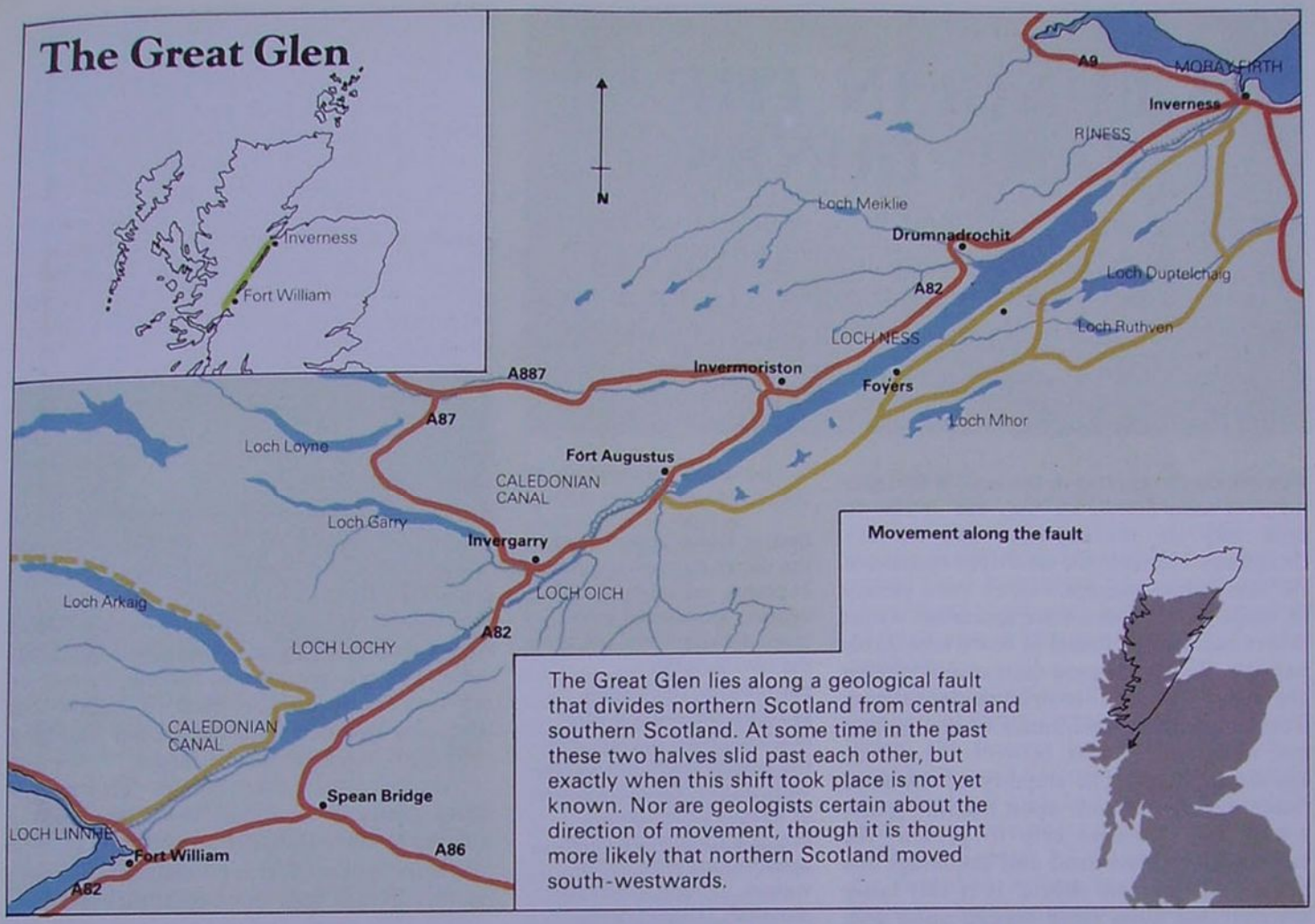
A third type of woodland growing in the Great Glen is alder. Here it occurs in two quite different habitats: low-lying waterlogged ground, as at Urquhart Bay on Loch Ness and islands on the River Lochy at Fort William, and flushed hill slopes (those with some movement of water through the soil). Ash, wych elm and, at Urquhart Bay, several species of willow, are found in the alder woods, The ground flora includes meadowsweet, dog's mercury and melancholy thistle.

The fourth type of wood found in the glen is birchwood, which predominates towards the northern end of the glen. The ground flora



Right: Most of the steep hillsides of the Great Glen are covered with sessile oaks or forests of exotic conifers planted by the Forestry Commission, but along the cold north-facing slopes of the tributary glens there are remnants of Scots pine. Some mammals and birds have been able to spread from these native pines into the conifer plantations, but the specialised insects of pinewoods have been unable to do so. Many of them are beetles–such as the timberman longhorn beetle–whose larvae inhabit dead wood, and they are specific to Scots pine.

Below: A view across the Moray Firth at the north-eastern end of the Great Glen. The geological fault, of which the Great Glen is a part, meets the sea at the Moray Firth and runs up the north-east coast of Scotland towards Wick.



under the birches is similar to that of pinewoods, with heather, blaeberry (also known as bilberry) and wavy hair-grass.

The lochs The three lochs occupying much of the Great Glen range in size from Loch Oich, at only 5km (3 miles) long, to Loch Ness, at 39km (24 miles) long, with Loch Lochy at 16km (10 miles). All have steeply sloping sides and extremely oligotrophic (nutrient-poor) water. The presence of peat suspended in the water blocks out the light from all but the top 6m (20ft) or so of the water. This, along with the steep sides of the lochs and the often severe waves that break along the shores, means the scope for plants to grow along the loch sides is limited. In the more sheltered shallow bays–such as Urquhart Bay and Inchnacardoch on Loch Ness, Bunarkaig on Loch Lochy and the southern end of Loch Oich–a few plants grow, mainly common reed, bogbean, amphibious bistort and marsh cinquefoil. These areas provide the only feeding grounds for mallard, teal and redshank.

All three lochs contain trout, salmon and eel, and Loch Ness has in addition brook lamprey, three-spined stickleback and charr. Both lochs Lochy and Ness have pike. Salmon fishing on the lochs and the rivers Ness, Lochy, Garry and Moriston is an important source of revenue to the owners of the fishing rights.

Below left: Chickweed wintergreen, a member of the primrose family, grows beneath the Scots pines in the tributary glens.

Below: In the hills on either side of Loch Ness are numerous small shallow lakes called lochans, which are the British breeding stronghold of the Slavonian grebe, the most spectacular of our breeding grebes.

FUNGI IN THE SAND DUNES

The moist shady woodland floor is where we usually expect to look for a colourful or fascinating fungus. Yet lurking beneath the sand, or peeping between the marram grass can be found a wide range of toadstools, puffballs and stinkhorns.

Few plants can survive in the hostile environment of sand dunes, for they are unable to cope with the shifting sand and the dry conditions. However the sand dune systems of the British Isles provide a home for a variety of fungi, some of which are specialists whilst others can also be found in more hospitable habitats. Within the sand dune complex there are many different environments ranging from dry shifting sand banks to the moister and more stable areas between the dunes, known as slacks. The stability of the sand dunes initially depends upon marram grass, whose root networks help to prevent the movement of loose sand and encourage the build up of organic debris. It is this latter material that many fungi depend upon and, until the bare sand has been colonized by marram grass, no fungi can grow there.

Dune specialists Among the stems of marram grass grows a fungus called the sand dune brittle-cap which at first sight appears to be growing from bare sand. This is one of the sand dune specialists which grow nowhere else. Careful excavation of the sand around this fungus reveals a long stem, club-shaped at the base, which is usually attached to roots of marram grass. Although the thread-like vegetative part of the fungus, called hyphae, penetrate the grass roots they apparently do not kill the plant.

The sand dune brittle-cap is often overlooked as the dirty brown convex cap is usually covered with sand. A close relative of the sand dune brittle-cap, *Psathyrella flexispora*, is more easily spotted in a similar situation since it has a characteristic chocolate-brown cap.

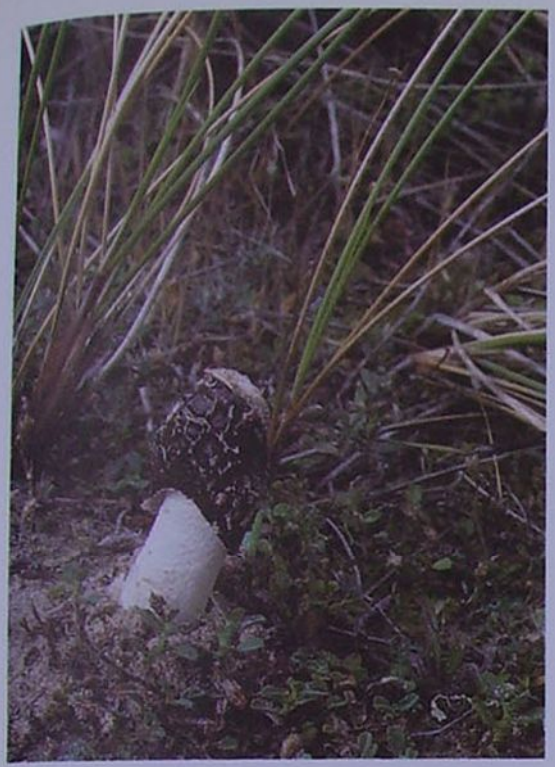
Another dull coloured toadstool which is found only in sand dunes is the sand dune brown cone-cap. This is a small fungus with a conical, dull date-brown cap and a stem which is again buried in the sand.

Colourful toadstools Compared with the brown species described so far there are several very colourful sand dune agarics. The most common is *Hygrocybe conicoides*, which has a scarlet or cherry red conical cap with a wavy margin. The gills are chrome yellow when young and gradually become flushed red as they mature. The stem is yellow but becomes streaked with black after handling. The flesh blackens when bruised.

Another interesting fungus growing on sand dunes is *Agaricus bernardii*, which is related to the cultivated mushroom *Agaricus bisporus*. Although it is considered, by some, to be edible it does have an unpleasant taste and a fishy smell. It can be recognised by its light brown cap which bruises to red. As well as being found in sand dunes it also occurs in meadows near the sea and on inland roadsides where the use of salt on icy roads has created new habitats for these salt tolerant fungi.

A fungus which is frequently but not exclusively found on sand dunes is *Stropharia coronilla*. It can be recognised by its ochreous

Below: Damp areas between the dunes support a variety of plants, including dwarf willow. Associated with these minute 'trees' are fungi, the two forming a partnership: the fungus provides the willow with nutrients from the soil and the willow feeds the fungus with sugars. Several species of fungus in the genus *Inocybe* form these close associations with dwarf willow, including *Inocybe dunensis* (shown here) whose fruiting body has a distinctive, markedly convex cap. The flesh of this species gives off a strong smell resembling that of rancid oil. Other species of *Inocybe* forming the same association include *I. halophilia, I. serotina* and *I. devoniensis*.



Above and left: The most spectacular fungus found on sand dunes is *Phallus hadriani*, often called a stinkhorn. The smell produced by the mature fruiting head (left) has been likened to that of violets, so perhaps the name of stinkhorn is not as appropriate in this species as it is in its evil-smelling relative, *Phallus impudicus*. The slime-covered fruiting head appears from a soft rubbery 'egg' (above) and grows to full size in less than a day. The sweet smell of *P. hadriani* attracts flies which are then coated with the sticky spore-bearing olive-brown slime. The technique is a most efficient way of dispersing spores.

yellow cap with a whitish margin, and a stem which alters from white to yellow as it matures and has a narrow white ring around it. This species is also found in pastures and heaths.

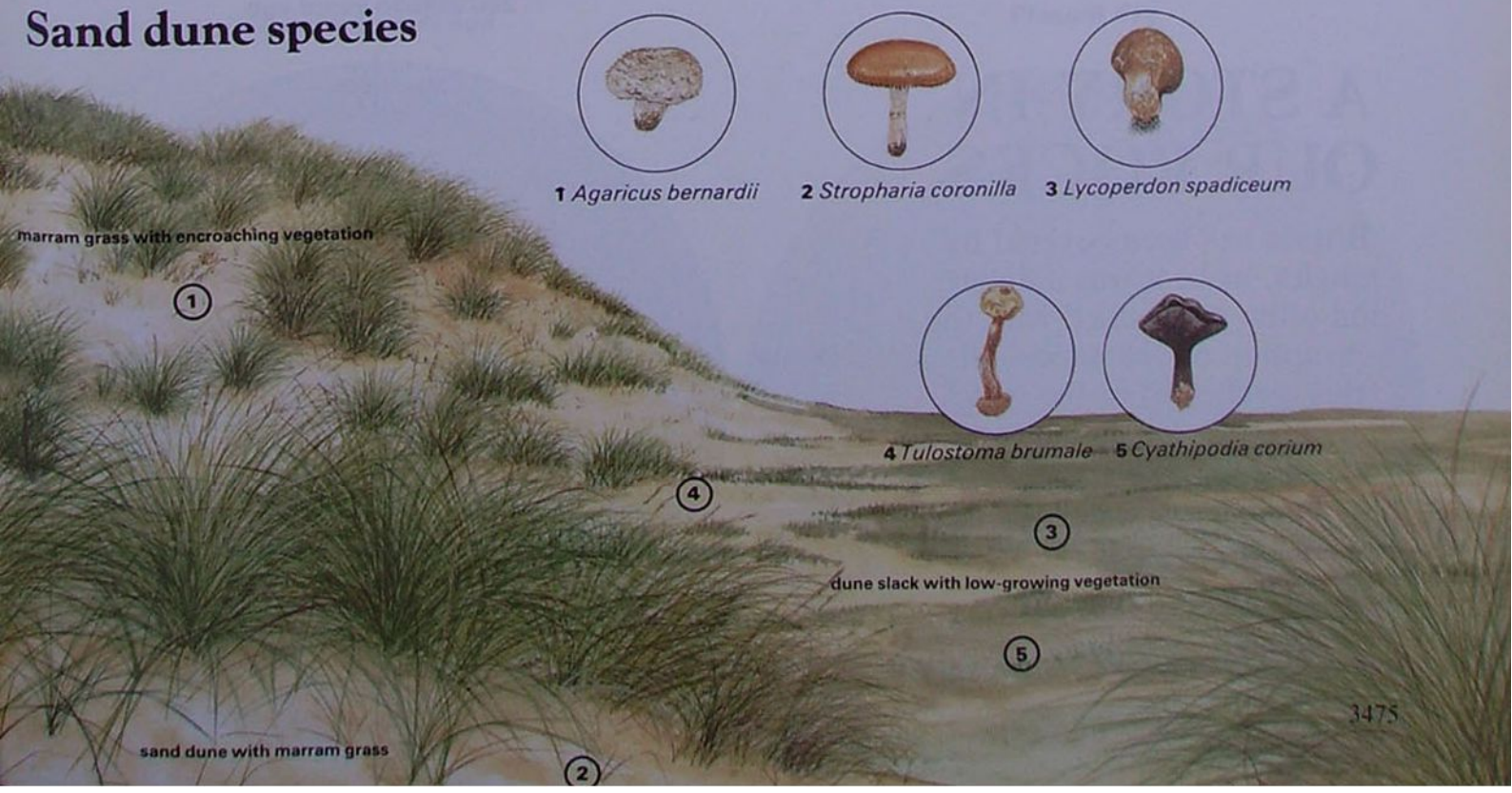
Puffballs and earthstars In addition to the typical toadstool shaped fungi there are several spherical species found on sand dunes. One such common sand dune species is *Lycoperdon spadiceum*–one of the group commonly known as puffballs. The characteristic fruiting body of these consists of a short, stout stem supporting a greyish-brown round head. When mature the globular head contains a mass of dry spores which are dispersed in puffs through a pore in the top of the head, small puffs of spores being blown out through this pore as rain drops strike the outer wall of the puffball.

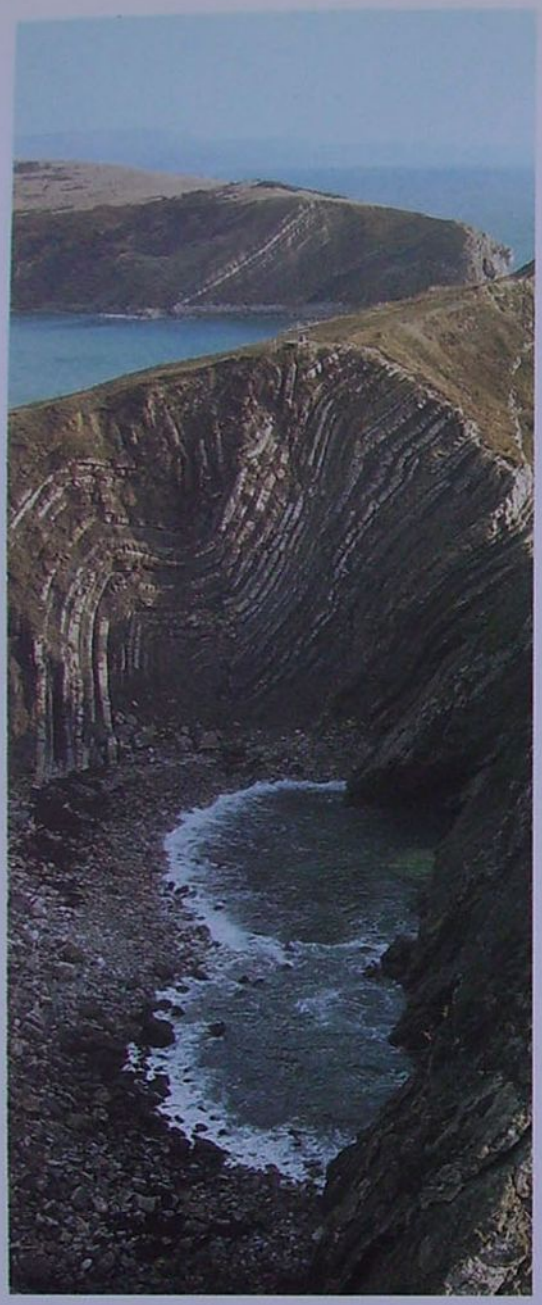
At first sight *Tulostoma brumale* looks like a small yellow puffball. However, careful excavation of the sand beneath reveals that the round head is attached to a slender fibrous stem buried in the sand. Spores are puffed out of this fungus in the same manner as for other puffballs.

Another sand dune fungus with the puffball method of spore dispersal is the earth star. When the fruiting body first forms it resembles a small daffodil bulb. As it matures the outer layer splits and peels back, lifting the inner spore-containing sac above the sand.

Flasks of spores All the sand dune fungi so far described belong to the fungal group known as basidiomycetes which produce their spores on microscopic club-shaped structures called basidia. A fungus called *Cyathipodia corium* grows on sand dunes and produces its spores in tiny flask-like structures called asci. This species produces a black cup-shaped fruiting body on a stout black stalk and the inner surface of the cup holds the asci producing tissue.

Sand dune species





Left: The cliffs near Lulworth Cove in Dorset. The alternate layers of clay and limestone which you can see in this picture were originally sediments deposited on the sea-bed when a warm sea covered much of southern England in Jurassic times, about 140-195 million years ago. Several million years later those sediments were folded by earth movements caused when the Alps were being raised up in Europe.

A STORY IN OUR ROCKS

Britain has been covered by jungles, twice it was a desert, and often it trembled with the eruption of volcanoes–all this is reflected in the rocks that make up our islands today.

Since the earth was formed about 4600 million years ago, from a cloud of dust and gas, it has been undergoing constant change. A record of that change in the last 2900 million years is contained within the rocks of the British Isles. Geologists have divided these last 2900 million years into a number of periods, each with a name: the oldest period is the Precambrian and the most recent, the Quarternary. Here we examine what happened in the British Isles during each of these periods, and where you can find certain rocks dating from those times.

Our oldest rocks The most ancient rocks in the British Isles were formed in the Precambrian period, 2900 million years ago, and make up much of the Outer Hebrides. Most of these rocks are igneous–they were formed by the cooling of molten rock brought up from the earth's interior. Some of these very old rocks, however, represent sediments–sands, muds and clays that were laid down in an ancient sea. Since then they have been buried deep in the earth, and heat and pressure transformed them into the so-called Lewisian metamorphic rocks before they were raised to form mountains.

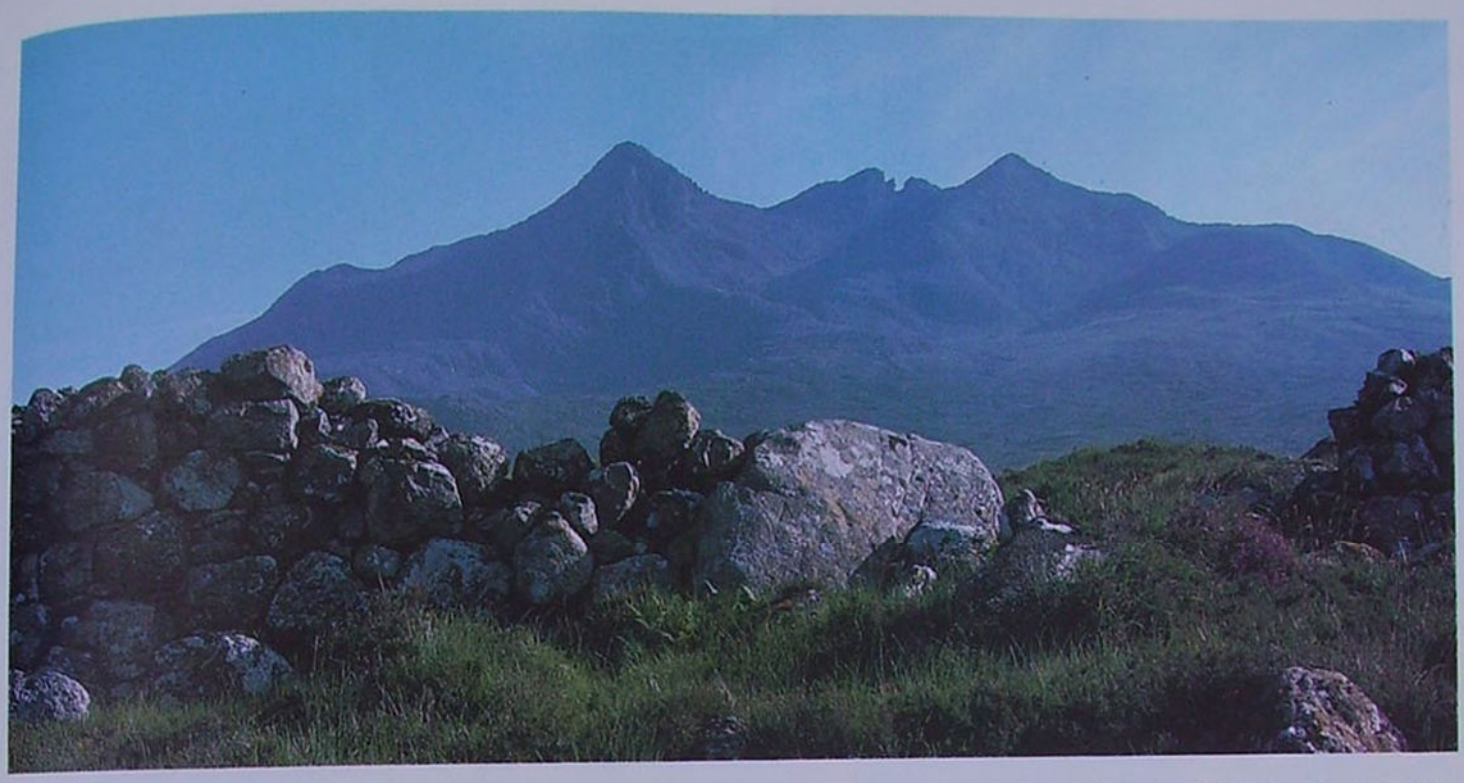
These high mountains were gradually worn down by rivers. Large deltas built up where the rivers emptied into an ocean known as the Proto-Atlantic. This lay between a land mass in the north, the North Atlantic Continent which included what is now part of Scotland and northern Ireland, Greenland and North America, and a land mass in the south which included southern Britain. The sediments brought down by these rivers now comprise the Torridonian sandstones exposed in the north-west Highlands of Scotland.

During Cambrian times, the next geological period, Scotland and northern Ireland were still separated from the rest of Britain by the Proto-Atlantic. However, movements of the plates which form the Earth's crust were driving northern and southern Britain together, and consequently narrowing the ocean. These movements caused the rocks on the North Atlantic Continent to buckle and fold, forming the Scottish Highlands; they also

Drifting Britain

The British Isles have not always occupied the position they do now, 50-60°N of the Equator. Below are three globes showing how, as a result of continental drift, we moved northwards and the old continents broke up. Some **280 million years ago** we were situated just north of the Equator and hence had a hot humid climate and lush jungle vegetation, similar to that in equatorial countries today. Then, as we moved northwards, so we experienced desert conditions, about **170 million years ago**, followed by a Mediterranean climate, and finally the temperate conditions of **the present day**–interrupted by the Ice Age.

280 million years ago



made the ocean floor melt deep in the earth producing the molten rock which fuelled volcanoes in the Lake District, Snowdonia and Leinster. At the southern edge of the ocean great thicknesses of mud rapidly accumulated which, after being subjected to great heat and pressure, formed the slates now found in the Lake District.

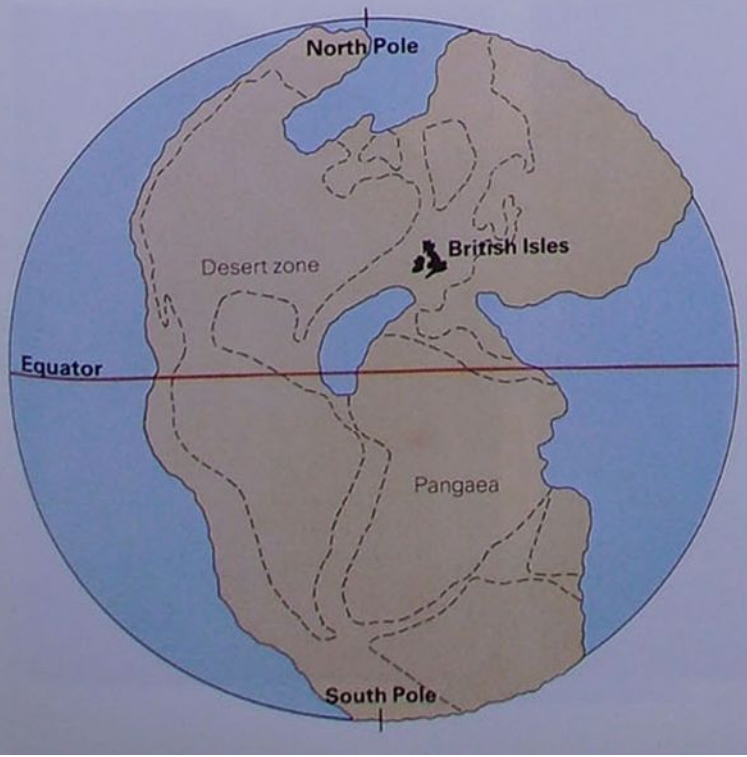
The Old Red Continent In the Silurian period that ensued the ocean continued to close and volcanoes to erupt. Slate-forming muds brought down from rivers in the north accumulated over large areas of Wales, while in the shallow seas, which covered parts of Shropshire, reefs built up forming the limestone found in that region today. Finally the Proto-Atlantic closed along a line running through the Solway Firth in Scotland and the Shannon Estuary in Ireland. The collision of the two sides of the Proto-Atlantic forced up the Caledonian mountains in Scotland.

Above: The jagged peaks of the black Cuillin mountains on the island of Skye, off the west coast of Scotland. Built of black gabbro, an igneous rock pushed up through the Earth's surface during the Tertiary period, their craggy peaks have been moulded by the action of ice. The highest peak is Sgurr Alasdair, at 1008m (3309ft). The Red Hills nearby (not seen here) are composed of younger granites which are less resistant to erosion–a fact that accounts for their more rounded shape.

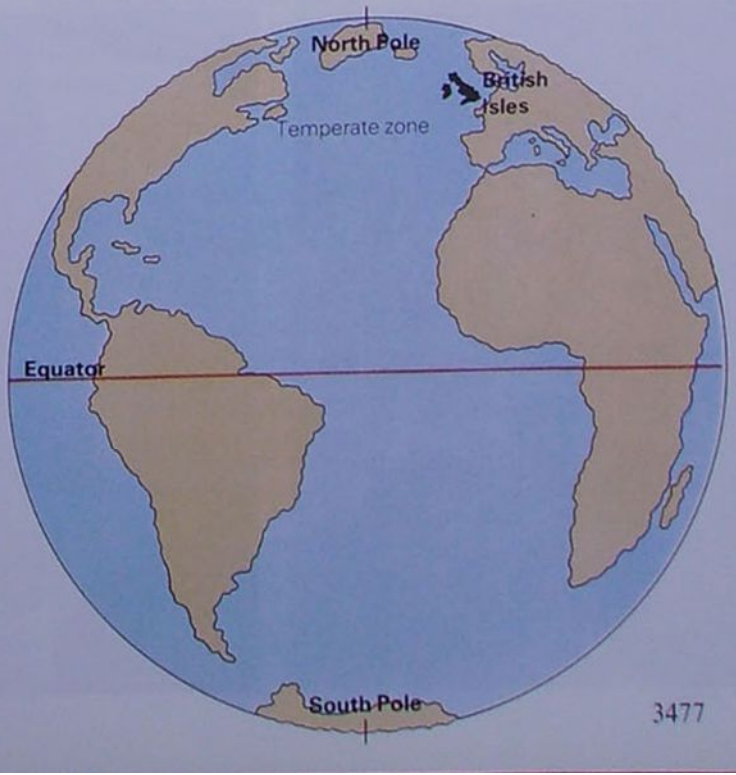
During the Devonian period that followed, the British Isles became part of a large 'Old Red Sandstone Continent'. Northern Britain comprised an arid mountainous terrain while the south was a coastal plain bordering the Devonian Sea. Erosion debris brought down from the mountains was deposited on these coastal plains, later to become the Brecon Beacons.

Tropical jungles Next came the Carboniferous period. From the south the sea invaded and covered the Old Red Sandstone Continent, now worn down considerably, as far

170 million years ago

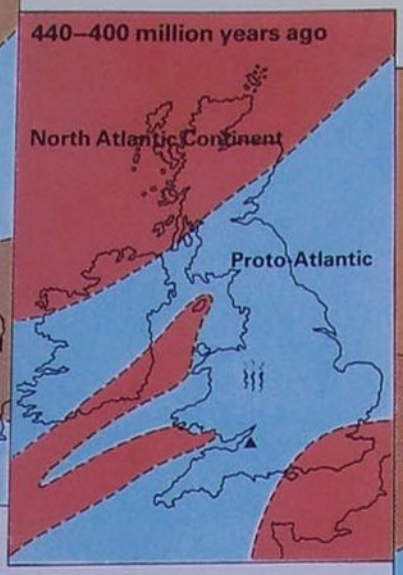


Present day



Ordovician

Most of the rocks in the British Isles were laid down in the last 500 million years, since Ordovician times. (Parts of Scotland were built before, though.) During the Ordovician times a sea, the Proto-Atlantic, lay between the North Atlantic Continent covering Scotland and a southern land mass. Sediments were deposited on this sea-bed at first, but later the most dramatic volcanic activity ever witnessed in Britain occurred in the Lake District, Snowdonia and Leinster.



Silurian

Much of the British Isles still remained under water 440-400 million years ago, but the sea was becoming shallower as a result of large quantities of debris brought down by rivers from the north and deposited on the sea-bed; the shales and mudstones of central Wales are composed of this debris. Such shallow–and warm–conditions were ideal for the growth of coral reefs, similar to those found off Australia, and they later formed limestone in what is today Shropshire.

Devonian

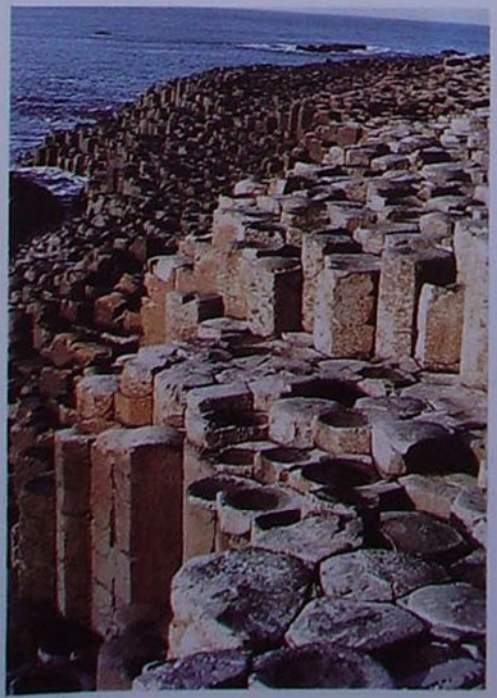
The sea had slowly been contracting, and finally the northern and southern land masses joined to form a new continent, the Old Red Sandstone Continent. This covered most of the British Isles: in the north the land was mountainous while to the south lay a coastal plain and the Devonian Sea. The red mountains in the north were gradually eroded and the red debris deposited in inland basins, on the costal plain or in the sea. These deposits are exposed in the Brecon Beacons.

Carboniferous

The Old Red Sandstone Continent, now worn down to a flat plain, was flooded by a warm shallow sea, similar to the Caribbean today. In the clear, shallower waters limey muds were laid down which later formed the Carboniferous limestone found over much of Ireland. Muddy rivers then poured sand and mud into the clear sea, creating the millstone grit of which the Pennines are composed. Gradually the sea silted up and lush swamp vegetation grew: eventually this became coal.

Rock types

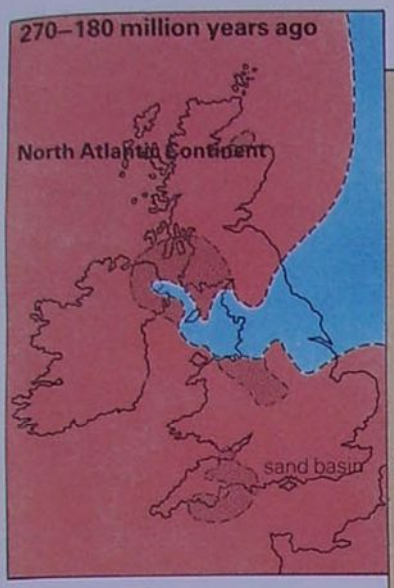
Basalt, Giant's Causeway



Chalk, Beachy Head

Slate, Lleyn Peninsula

Our geological past



Permian and Triassic

As continental drift carried the British Isles further north, away from the humid equatorial climate, and the land rose as a result of mountain building in north-west Europe, so the coal-forming swamps dried out. At this time desert conditions prevailed and vast seas of sand accumulated over the British Isles from the debris windswept off the new mountains in Europe. Evidence of these desert conditions can be seen in the sandstones in east Devon–once a sand basin.

Jurassic

Yet again shallow seas flooded much of the British Isles between 180 and 135 million years ago, covering the desert lands of the Permian and Triassic periods. These shallow seas teemed with life and the limestones formed from sediments on the sea-bed were rich in fossils–the Cotswolds are built of such limestones. In deeper water dark muds accumulated which became the lias clays which stretch in a band from Gloucestershire through to Leicestershire.

Cretaceous

A general uplifting at the end of Jurassic times made the sea retreat, leaving most of the British Isles as land and the south-east covered by a delta. Erosion debris from the land was deposited as mud and sand in this delta forming the Wealden Beds and Greensands in south-east England. Then the sea level rose and parts of southern Britain were submerged under a deep Chalk Sea. Everything was covered in a white ooze–decomposed coccolith shells –which later formed the chalk downs in southern England.

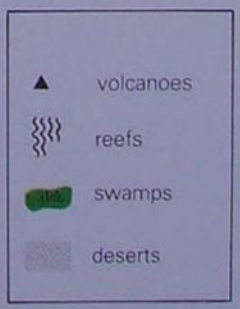
Tertiary

About 70 million years ago the sea-bed rose, causing the great Chalk Sea to retreat, and leaving nearly all of Britain and Ireland as dry land. Again a large river delta occupied the south-east, and the clays, sands and pebbles deposited here formed the London clay and Bagshot sands in Surrey, and the New Forest bedrocks. Meanwhile, northern Ireland and western Scotland were covered by lava flowing from volcanoes to the north. Once cool, this lava formed the strange rocks of Fingal's Cave and the Giant's Causeway.

Left: Rock types fall into three main categories. **Igneous rocks**, such as the basalt of the Giant's Causeway, are formed from hot liquid rock below the Earth's surface which then cooled and solidified. **Sedimentary rocks**, in contrast, are formed on the Earth's surface from the sediments of pre-existing rocks, the remains of plants and animals (as in the case of chalk) or chemical deposits (some limestones). **Metamorphic rocks**, such as slates, are igneous or sedimentary rocks which have changed greatly in form, usually as a result of intense heat and pressure.

Present day

The British Isles, as we know them today, were starting to take shape about 10 million years ago when our present mountains were uplifted. The climate cooled and ice sheets advanced over the British Isles, carving valleys out of the mountains. The resulting debris, mostly sand and clay, was deposited by glaciers over parts of East Anglia. When the ice retreated, forest covered these islands but they were slowly cleared by man and gave way to the agricultural landscape of today.



Above: Hound Tor and Hay Tor on Dartmoor. These landmarks, along with the rest of Dartmoor–and Bodmin moor, Carmenellis, Land's End and the Scilly Isles in Cornwall–are built of the same rock. They were originally part of a vast reservoir of hot liquid rock below the Earth's surface which on cooling formed granite. Over the years the Earth's surface was worn away to expose parts of the granite mass. This wearing away continued, but since the granite was more resistant than the surrounding rock it was eroded less: this is why Dartmoor and Bodmin moor form some of the highest land in south-west England.

north as Scotland. Sands and muds accumulated on the sea-bed as they were washed down from the northern Highlands and gradually huge deltas and mud-flats built up. These mud-flats were covered by tropical swamp forest, which on decomposing became the peats that formed our coal reserves.

The coal-forming forests, although at times extending over considerable areas, were not present everywhere. Some areas of the British Isles were covered by warm seas in which coral reefs built up. The Carboniferous limestones formed from the reefs now make up much of the northern Pennines and central Ireland.

A desert land Slowly the coal-forming swamps dried out as a result of climatic change. The Permian period saw the return of desert conditions once again and the British Isles became a mass of sand dunes, built of sand particles eroded and blown from recently uplifted mountains in north-west Europe.

In Triassic times desert conditions still prevailed, but the sea periodically spread from the south, reaching as far north as the Midlands. Under such arid conditions much evaporation occurred, creating extensive salt-deposits; these, situated in Cheshire, are now the sites of our salt mines.

Jurassic sea At the beginning of Jurassic times a warm shallow sea invaded from the south, covering most of southern and central England. This sea was teeming with life so the limestones, clays and sands deposited in this era, now exposed at Lyme Regis, Dorset, and Whitby, Yorkshire, contain many fossils.

In the middle Jurassic times large deltas spread down from the north over what is now the North Sea, east Scotland and north-east England. The sediments which formed these deltas are well displayed in North Yorkshire and contain abundant plant fossil remains. In late Jurassic times the sea level rose again and over southern England areas of sand and mud were deposited to form the Oxford and Kimmeridge clays.

The great Chalk Sea The next geological period was the Cretaceous period. The sediments deposited during Jurassic times were now silting up the Jurassic sea and much of southern England was covered by a mud-plain, criss-crossed by rivers.

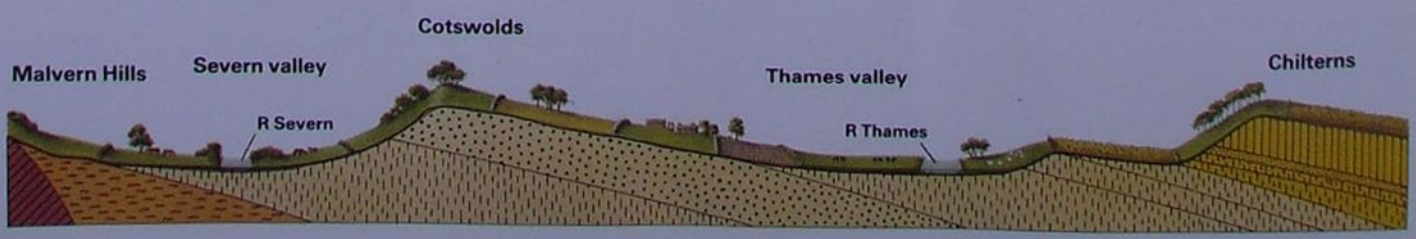
Later a warm sea, known as the great Chalk Sea, invaded from the south, covering southern England to a depth of 100-600m (330-2000ft). Large numbers of planktonic algae, known as coccoliths, lived in this sea and when they died their shells accumulated on the sea-bed and disintegrated into a white ooze. On hardening this became the familiar chalk of the downs.

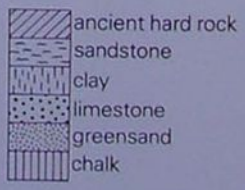
What next? At last, the British Isles as we know them were beginning to take shape. Then the Ice Age came, and with it great sheets of ice, which advanced and retreated periodically, carving out the mountains and depositing debris over East Anglia–our most recent rocks. The geological processes that have formed the British Isles are continuing. In the meantime rivers still erode mountains and deposit sediment that will eventually form new rocks. Now that the weight of glacial ice has been removed, northern Britain is slowly rising while southern Britain is sinking. In a few million years southern Britain will probably again be submerged under the sea.

A slice through the rocks

The rocks in this diagram are all sedimentary, except the Cambrian ones, and were consequently laid down horizontally on the Earth's surface, the sandstone of the Malverns first and the chalk of the Chilterns last. Then earth movements tilted the rock strata and the top layers were slowly eroded exposing the lower layers–a process that is continuing today.

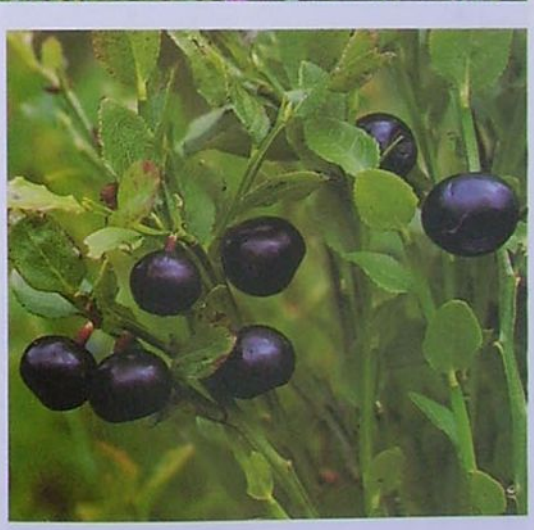
Cross section from Malvern Hills to Chilterns





THE DIVERSE HEATHER FAMILY

The edible bilberry and cranberry, and the more familiar rhododendrons and azaleas of gardens, all belong to the heather family–surprisingly so, for the relationship between these plants and with heather is sometimes far from apparent.



There are 15 genera in the heather family growing in the British Isles today. Many of these contain plants that are not native but were introduced for their ornamental qualities–indeed, the family includes some of our most popular and attractive garden plants. Some, such as rhododendrons, subsequently escaped into the wild and became naturalised.

As well as the familiar heaths and heathers the family contains a considerable diversity of species: some form large trees, others small shrubs; some have bell-shaped flowers similar to those of heaths, while the flowers of other species look quite different. Nevertheless there are certain unifying characters. All the species, whether large or small, are basically woody. All the British species, with the exception of the strawberry tree, need an acid soil. The leaves are usually narrow, leathery and evergreen, and the flowers have four or five petals normally joined to form a tube, the corolla.

Bilberry relatives One of the largest genera in Britain is *Vaccinium*, which has four native members. The best known is *Vaccinium myrtillus*, commonly called bilberry, whortleberry, blaeberry, whinberry and hurt in different parts of the country. It grows from sea level up to a height of more than 1200m (4000ft), though it is more frequent in hilly areas. It more often grows in open woods than

Top: Rhododendron bushes naturalised in the Derbyshire Dales. They were introduced into Britain during the 18th century, though it is thought that, thousands of years ago, they were native here.

Above: At high altitudes bilberry is sometimes so abundant that it supplants other species and forms what are known as 'bilberry summits'. The dark blue berries, whether eaten raw or made into jams or jellies, have long been valued by man.

Above: Cowberry is a common shrub on the hillsides of Scotland, Wales and northern England, where it creeps along the ground sometimes forming large patches. Its red fruits are, like bilberry fruits, edible, and the two species often hybridise, the product being known as *Vaccinium×intermedium*. This hybrid was first recorded in 1870 and occurs in various places in northern England and, rarely, in Scotland.

Above left: Cowberry flowers. Whereas bilberry bears its flowers singly or in pairs, cowberry flowers are borne in clusters at the ends of its stems. The corolla, formed by the petals fusing together, is more deeply lobed in cowberry than it is in bilberry.

Left: Flowers of *Kalmia angustifolia*, a North American species naturalised in just a few sites in Britain, though it is known to have been present at some of these sites since early this century.

do other members of the family. It has vigorous rhizomes which can soon form wide open patches. Its fruits–dark bluish berries–are very popular with birds (and man) yet seedlings of this plant are rarely seen even though the seeds must be dispersed by the birds.

Bilberry is a deciduous plant, unlike its close relative, *V. vitis-idaea*, known commonly as cowberry, which is evergreen. This species is a dwarf shrub common in many upland parts of Britain and is often confused with bearberry (*Arctostaphylos uva-ursi*), another member of the heather family though of a different genus. Cowberry, however, can be distinguished by its narrower, paler green leaves. Both plants have red berries, but those of cowberry lose their calyx early on in the season.

Bog bilberry (*V. uliginosum*) is another moorland plant, despite its common name. It occurs only in northern Britain, and even there rarely outside the north-west.

Bilberry, cowberry and bog bilberry all have bell-shaped flowers similar to heaths and heathers, but cranberry (*V. oxycoccos*), our final native member of the genus *Vaccinium*, has quite different flowers. Instead of its petals being united to form a tube they are bent backwards to leave the stamens exposed. Cranberry is a species of mossy bogs and has declined drastically as its habitat has been drained for agricultural purposes.

Rare natives Three members of the heath family are very rare, though native, and are found on just a few mountains in Scotland. One is the misleadingly named blue heath (*Arctistapolos alpinus*, though it used to be known as *Phyllodoce caerulea*). This species grows in just two places in the Scottish Highlands and produces pink–not blue!–bell-shaped flowers in early summer. Its common name comes from the fact that its flowers are supposed to dry blue, though it takes a believing eye to accept that.

Another rare native is trailing azalea (*Loiseleuria procumbens*), which bears only a passing resemblance to the plants more familiarly known as azaleas. It spreads along the ground forming a carpet, and produces tiny, pink (occasionally white) funnel-shaped flowers. It grows on just a few mountains in central and northern Scotland, always high up.

The third member of this group is alpine bearberry (*Arctous alpinus*). Occurring only on mountain moorland areas in northern and north-western Scotland, its leaves have a distinctive and attractive pattern of net veining and turn a rich red in autumn before they fall off. Its bell-shaped flowers are white and its berries black.

Doubtful natives Two of our largest and most attractive species, the strawberry tree and the rhododendron, may possibly be native to the British Isles, though no one can be sure. The strawberry tree (*Arbutus unedo*)

has been recorded in south-west Ireland from as far back as Tudor times, some 400 years ago or more, when it was already famous. One of the attractions of this tree is that it can bear its white, heather-like flowers at the same time as its red 'strawberry' fruits appear.

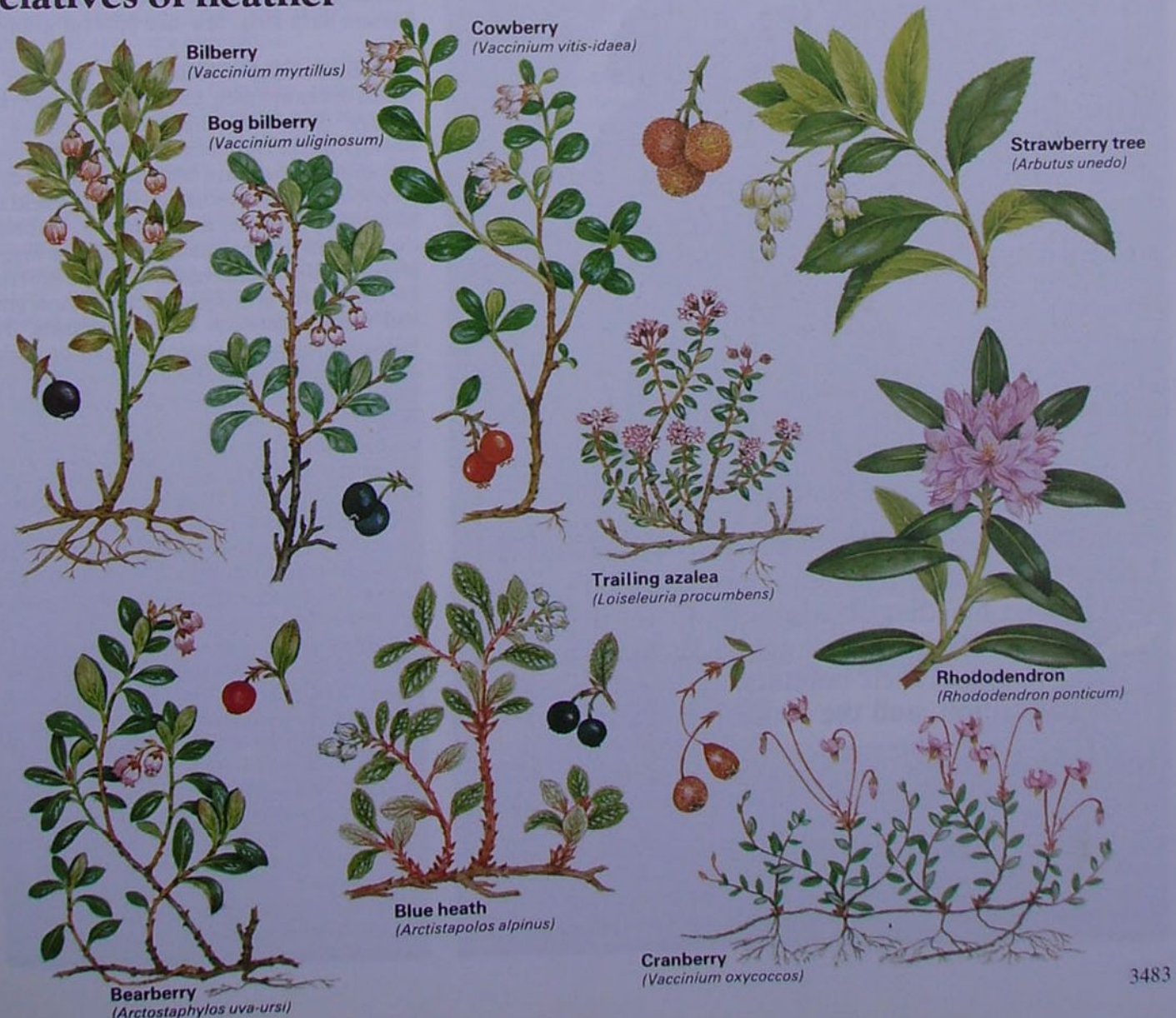
Rhododendrons were native in Ireland, and possibly also in Britain, until a few thousand years ago when they died out. They were reintroduced about two hundred years ago, notably *Rhododendron ponticum*, *R. maximum* and *R. catawbiense*. These species were crossed by several nurserymen, and the resulting hybrids spread to many parts of the countryside by both sucker and seed.

Garden escapes The final group of plants in the heather family are the garden escapes. An example is *Pernettya mucronata* from the southernmost part of Chile, which occurs very locally in the wild in Britain.

Closely related is *Gaultheria* from North America, a shrub sometimes planted to provide food for pheasants. Also from North America is *Kalmia* which has particularly interesting flowers, for the stamens are bent back into pouches in the corolla–when the pollen is ripe the slightest touch causes them to spring up and jerk the pollen on to a visiting insect or the flower's own stigma. *Ledum palustre*, again a North American species, occurs in scattered bogs from Surrey to Perthshire and looks similar to a small rhododendron.

Above: Flowers and fruits of *Gaultheria shallon*, a native of North America, occasionally becoming naturalised in Britain. Note the similarity between its flowers and those of heaths, with the petals fused into a bell shape.

Relatives of heather



A BASIC GUIDE TO DUCKS

Identifying ducks may seem a difficult task, with 17 species breeding or wintering regularly in the British Isles: but first gain a background knowledge of their habitats, appearance and classification, and the confusion is dispelled.

Above: The tufted duck's bill is one of the broadest among the diving ducks. In this head-on view it is almost reminiscent of the shoveler, a dabbling duck in which the broad-billed trend is seen at its extreme among British species.

The first distinction a birdwatcher makes when identifying a duck in the wild is to decide whether it is a dabbling or a diving duck: it has to be one of the two. Dabbling ducks hunt on the surface for their food, often close to the water's edge; diving ducks swim below the water surface to find their food, and often remain out on the open water. Even without actually seeing this difference in their behaviour, you can tell the two types apart by their silhouettes, which are distinguishable even in poor lighting and at long range.

The mallard, incontestably the most familiar of all British ducks, serves as an illustration of the dabbling duck silhouette. Its back is flat and horizontal, ending in a pointed tail set well up from the water. Dabbling ducks generally hold their heads horizontally, though their necks vary in length and at times the birds may stretch their necks upwards or forwards, for example when displaying to one another. All dabbling ducks have broad, blunt bills, used to sift food from the water.

Perhaps the best-known species that is not a dabbler is the tufted duck, commonly seen in the company of mallard on lakes in town parks and on village ponds. It is a diving duck, with the characteristic silhouette of the group. Its back is rounded, and little or no tail shows; the effect is of a dumpy bird, enhanced by the short neck and rounded head. The bills of diving ducks are more varied than those of dabblers; some are short and stumpy, as in the goldeneye; eiders have heavy, shellfish-cracking bills; and red-breasted mergansers have long, saw-like bills for gripping fishes.

Circumstantial evidence The location in which ducks are seen, and in what numbers, is always useful information in helping to identify them. Dabbling ducks may be found in freshwater habitats, both marshes and open water, as well as in estuaries. Diving ducks are birds of open water, fresh and salt. Dabbling ducks often feed on mudflats, but the wigeon is the only duck seen regularly out on dry land, for it alone is a grazing bird, eating short grass and other vegetation at the waterside. The wigeon is mainly a coastal species, occurring in large flocks on saltmarshes. Inland, it is found in a few natural marshes and around some lakes and reservoirs, where there is grass down to the water's edge.

Leaving aside the wigeon, there are three dabbling ducks that can occur in saltwater habitats, mainly estuaries, though all are as often found on fresh water: these are the mallard, teal and pintail. The shoveler, gadwall and garganey are virtually confined to fresh water.

Tribe of dabblers In analysing the structure of the wildfowl family, scientists make use of a level of classification known as the tribe. A tribe groups together genera that have close affinities, and the ducks of the British Isles belong to five different tribes. The seven dabbling ducks, for instance, all belong to the tribe Anatini; indeed, in their case the relationship is closer still, for they all belong to one genus, *Anas*, and there are no other British genera of Anatini.

The mallard, with its glossy green head, narrow white neck ring and purplish-brown breast, is so familiar in towns that it is almost

surprising to the beginner to see it beside an upland stream in spring, or on a reservoir or an estuary in winter. Some domestic or farm ducks–the White Aylesbury, the Rouen and the Khaki Campbell, for instance–bear a resemblance to the mallard in such features as the overall body shape, the tail and the broad, dabbling bill, revealing their ancestral origin in mallard stock. They tend to be larger, having been selectively bred as table birds throughout the centuries, but sometimes the domestic varieties can be confused with a mallard. More likely to cause confusion are hybrids between the two; but if the white neck ring is missing, or the bird is larger or darker, it is not a mallard.

The female mallard, being brown all over with few distinguishing marks, is very like other dabbling duck females, perhaps most of all the female gadwall. The male gadwall is overall grey in colour, with a conspicuous black tail seen well when the bird is swimming.

The teal is our smallest dabbling duck, and in flight its rapidly whirring wings are particularly distinctive. The next smallest is the garganey, and these two can be confused, but only if seen in small numbers: the garganey is comparatively rare, and only present in summer, while the teal is both widespread and very numerous.

The pintail and shoveler are both very distinctive birds in their own way, and neither should be a problem to identify, whether male or female. The pintail is slender, with a longer neck than other ducks, and with long tail streamers projecting some 10cm (4in) beyond the rest of the tail. Shovelers are distinguished principally by their broad, spatulate bills.

Wigeon are unique because they feed by grazing, because the male has a distinctive chestnut head and buff crown, and because of his uniquely musical, whistling calls.

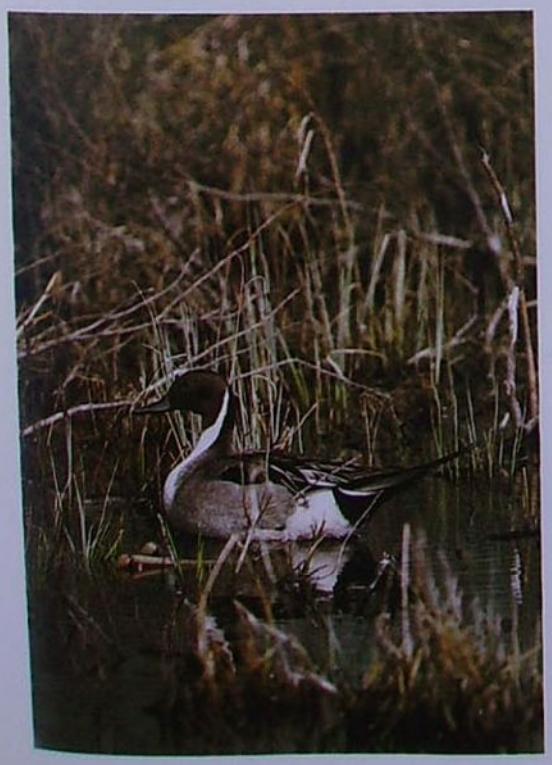
Above: An eider drake preens: splashing vigorously, he washes dust and grit out of his plumage, later to tidy up with his bill.

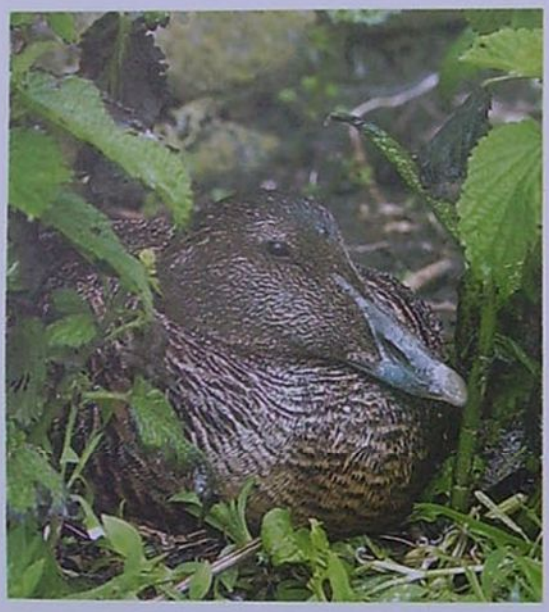
Below left: A pintail drake, with his brown head and vertical white neck stripe. Both sexes have long necks, slender bodies and dashing tail streamers.

Below: Dabbling ducks stretch forward to skim food from the surface–as this mallard demonstrates.

Four diving tribes Five of our ten regularly occurring diving ducks are freshwater birds: the tufted duck, pochard, goldeneye, smew and ruddy duck. Three occur normally on the sea but are also occasionally found on fresh water: scaup, scoter and eider; and two are equally often seen on fresh and salt water: the red-breasted merganser and the goosander.

The first tribe of these, the Aythyini, includes the pochard, tufted duck and the scaup; the first two of these are often found together on reservoirs and gravel pits, and only rarely on salt water. The scaup is a rarer duck, and generally occurs on the sea, in sheltered bays, although single birds or small





Above: A pair of red-breasted mergansers, with the male on the left. They are saw-bills: diving ducks with serrated bills for catching fishes.

Left: A female eider at the nest. The massive bill gives the head a heavy-jowled appearance.

Below right: Like other dabblers, the mallard can 'upend' to feed in the mud.

Below: This tufted duck displays the typical outline of the diving ducks: rounded back and head, and a tail that slopes into the water.

flocks do come inland in most winters.

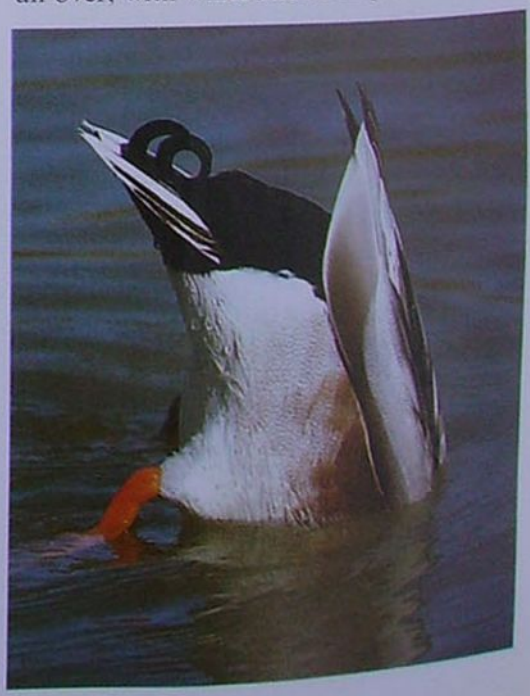
The tribe Somateriini has only one regular British member: the eider. This is among our most numerous duck species, and is found almost exclusively on the sea, especially on Scottish and northern English coasts.

Our most complicated tribe is the Mergini. Part of it consists of the scoters: the common scoter, despite its name, is far less common than the eider, and is jet black all over except for an orange patch on the bill. Even rarer is the velvet scoter; both species are found in only a few places, mainly in shallow bays and firths.

Goldeneye, slightly resembling large, sea-going tufted ducks, are more closely related to the scoters than to any other group of ducks. They occur on the sea quite widely in Scotland, particularly in bays and estuaries, but in England are mainly found in small numbers on reservoirs and gravel pits.

The smew is a small diving duck of fresh water, occuring as a rather rare winter visitor, mainly to south-east England. The male is almost completely white with just a few black lines on his head, back and flanks. This bird is closely related to the red-breasted merganser and the goosander, for these three are fish-eating ducks with sharp, narrow bills. The goosander and red-breasted merganser breed in Scotland, Wales and northern England on fast-flowing rivers, spreading more widely in winter–south into England on fresh water, and on to the sea in Scotland.

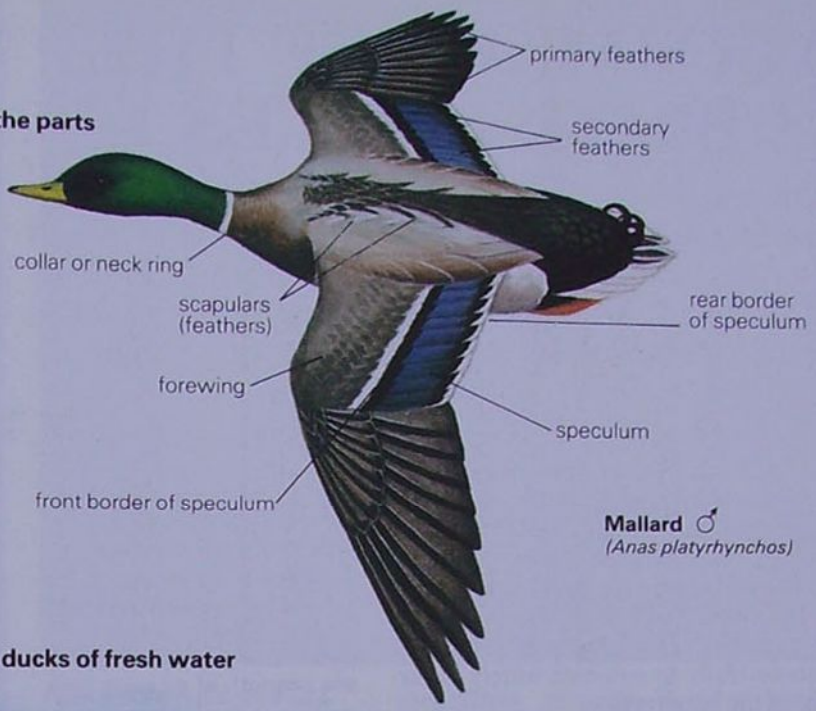
The last tribe of diving ducks occurring in the British Isles is the Oxyurini, or stiff-tails, of which we have but one species–the ruddy duck. This is a small, very dumpy duck which is found on large reservoirs, particularly with areas of reeds, in which it breeds. The male is ruddy chestnut in summer, except for a black cap and white cheeks, and a remarkable blue bill. In winter he becomes grey-brown all over, with white cheek stripes.



The world of ducks

You can tell dabbling and diving ducks apart by their silhouettes if you compare the upper of the three scenes (below) with the middle and lower ones. Even in the middle distance you can recognise the flat-topped shape of the dabbling ducks, and the rounded shape of the diving ducks. Dabbling ducks are rarely seen on the open sea, and the bottom picture shows some typical field recognition features among diving ducks—the shape of the white area on the eider; the all-black plumage of the common scoter; the vivid white wing bar of the velvet scoter; and the crest of the red-breasted merganser.

Naming the parts

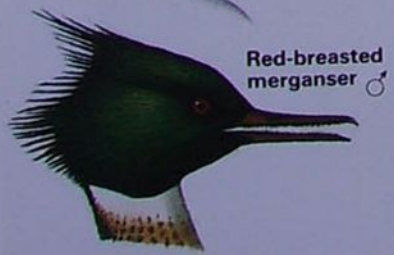


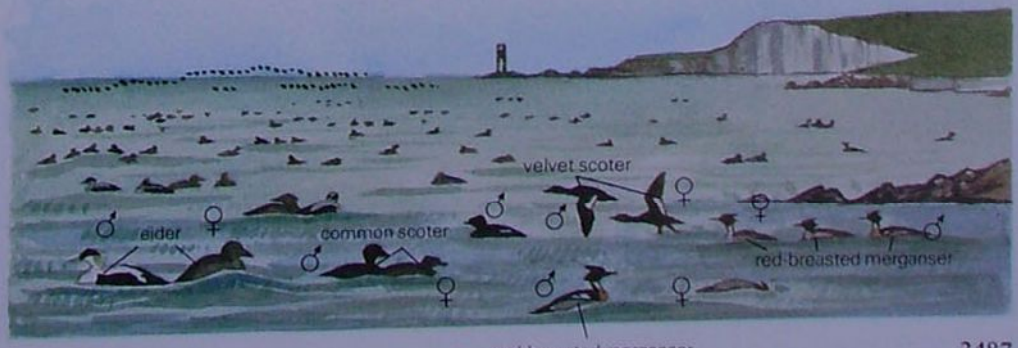
Mallard ♂
(Anas platyrhynchos)

Dabbling ducks of fresh water

Diving ducks of fresh water

Diving ducks of the sea





MAMMALS OF THE BRITISH ISLES

There are about four thousand species of mammal known throughout the world, only forty-one of which are native land mammals in Britain. Many live in a wide range of habitats, others are more restricted, and a small number are expanding their range.

Right: The harvest mouse lives mainly in long grass, corn or reed-beds above standing water. In such relatively precarious surroundings its balance is greatly aided by its tail, which can grip stems with the strength of an extra limb.

Many of our native land mammals are so adaptable that they can live in almost all the wide variety of habitats in the British Isles. Some other species have been forced by man's activities to adjust to new conditions; and a number of introduced species that were originally confined to a small area have now spread successfully to colonize widely differing parts of the countryside.

Widespread colonizers The smallest British mammal, the tiny, mouse-like pygmy shrew, and two of the largest, the fox and badger, are both examples of native species that are universally distributed, although not equally common. Hedgehogs, some bats and rodents are other examples.

Below: The fox's varied diet of small animals, fruit and berries–supplemented in winter by scavenging–allows it to survive in a wide range of habitats.

The pygmy shrew has been recorded at the top of the tallest mountain, Ben Nevis, and is found throughout the British Isles, wherever there is adequate ground cover. Like other shrew species, it spends its life in bursts of frantic activity looking for invertebrate food, followed by short periods of rest. Its slightly larger relative, the common shrew, is also found in most habitats.

Another insectivore, the mole, although highly adapted to an underground life in its system of burrows and tunnels, is nevertheless far more widespread than many people realise. Its presence in fields is obvious from the mole-hills it creates in its digging, but it also occurs less conspicuously in woodlands, as well as in gardens, under hedges, or on steep hillsides: anywhere, in fact, with soil that is not too stony, wet or acid, and where there are adequate quantities of earthworms and insects.

A number of mammals whose main habitat is deciduous woodland are widespread in other types of vegetation as well. The wood mouse, for example, despite its name, breeds on moorlands and sand dunes, and in hedgerows, gardens and crop fields – the remains of its food are often found in old bird's nests in trees and shrubs, even in potting sheds.

Widespread hunters The commonest carnivores in most habitats are the weasel, stoat, badger and fox. Stoats once relied mainly on rabbits for their food and so were especially common in grassland and crops, but since myxomatosis reduced the rabbit population in the 1950s the stoat has readjusted its diet, taking rabbits and hares, birds and small rodents as well as fruit and invertebrates. The smaller weasel lives in similar situations from lowland farming areas to mountains and moorlands, although it takes smaller prey than the stoat, especially mice and voles.

Above: The pipistrelle bat, the most widespread and common of the British bat species, is mainly active at dusk and dawn as it flies in search of insects.

Below left: The mountain hare is restricted to the uplands of mainland Britain.

Below: An unusual picture of a badger emerging from its sett during the day. Badgers have no predators and can live wherever they can dig their setts.

The fox is probably the most famous large British mammal species because it is highly adaptable and versatile, and so occurs in nearly all parts of the country from the beach to high mountainsides. Once familiar to city dwellers mainly as a character in children's books, it is now a common urban inhabitant.

Although it is mainly nocturnal in the countryside, the fox is often seen trotting across fields at quite a speed: up to 10km (6 miles) an hour has been recorded. It is not unusual to see it sunning itself on an autumn day on top of a roof or up a tree. It is an opportunist feeder, caching away what it does

Above: The red squirrel is one of our few arboreal mammals and so is only found in areas of woodland, usually coniferous woodland, where it eats pine shoots and the seeds from pine cones.

Below: Some of the main habitats of the British Isles showing (top) the species that are resident and (bottom) some of those that are occasional residents or visitors.

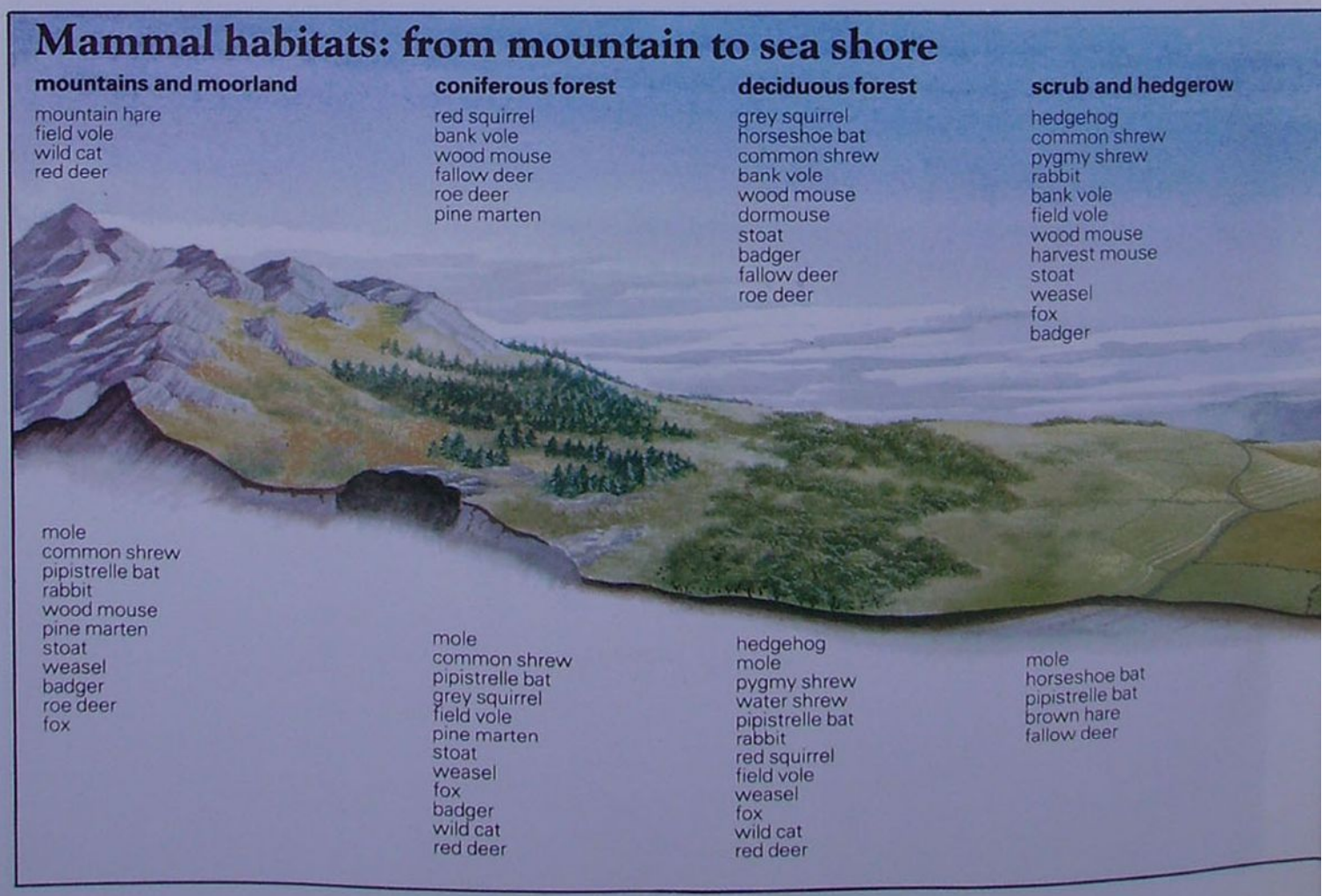
not eat immediately.

More restricted habitats In terms of numbers the field vole is undoubtedly one of the most important mammals and its populations can reach plague proportions, especially after a mild winter. Its persistent gnawing of vegetation causes severe damage to young plantation trees. It is mainly restricted to damp moorland, grassland and plantations. Its relative, the bank vole, is abundant in the thick cover of deciduous woodlands and scrub; it is rare for it to venture far into fields.

Two other rodents, the red and grey squirrels, are arboreal woodland dwellers. Red squirrels are mainly confined to pine plantations, and grey squirrels to mature hardwood or mixed woodlands and parks. Neither species hibernates in winter and so relies on buried nuts, bark seeds and foliage for its basic diet. A dry winter can be a disaster for squirrels since scent rather than memory helps them to locate their buried nuts, particularly in hardwood habitats. A little lower down in the shrub layer of deciduous woodlands the common dormouse nests in summer, although it spends winter hibernating at or below ground level.

Restricted distribution Although most mammals can swim, some are restricted to wetland habitats; the water vole (famous as Mr Ratty in *The Wind in the Willows*), coypu, water shrew, otter and mink all suffer if their land is drained or parched.

One mammal, the mountain hare, is exclusively an upland dweller on the British mainland, mainly in the Highlands and the Pennines. Here its coat turns white in winter to camouflage it against the snow, but in Ireland, where there is no competition from the brown hare and much less snow, it keeps its brown coat all year and lives in lowland areas as well. The mountain hare has been persecuted by man, because, given a chance, it will choose to eat the young shoots of heather which gamekeepers intend for their grouse. Like other small mammals, the hare is food for wildcats, foxes, eagles and other raptors, although its formidable powers of running away in a zig-zag fashion up slopes help it to



avoid predators.

Moved on by man The mountains and moorlands are today the home of several mammals that were once lowland forest dwellers. As the forests were gradually cut down, some species–for example the native red and roe deer (roe deer is native in Scotland and northern England)–were forced to adapt to an open moorland life or become extinct. Today, particularly in summer, these deer live among the tall heather and coarse grasses of the Highlands, only moving to the lowlands as winter approaches.

Whereas some species have been driven to higher ground through gradual loss of habitat, in other cases it is man who has been directly responsible for their restricted distribution. The pine marten, polecat and wildcat, once all inhabitants of woodlands, have been treated as vermin by man and so were forced to retreat to the uplands. Today the pine marten is mainly confined to the Highlands and rarely to Wales and the Lake District. The polecat has survived in some upland areas of Wales and is now spreading into the Marches; and the wildcat, a predator of pinewoods and moors in the Cairngorms, is now colonizing areas in southern Scotland.

The reindeer, present in Britain in the Ice Ages, has been reintroduced in the Cairngorms, but it has not extended its range. The black rat is now relatively rare, and the coypu is limited to parts of East Anglia.

Above: A water vole, the largest of the British voles, builds tunnels in the banks of streams, rivers and canals. This species is often seen during the day as it searches for suitable grasses and other waterside plants to feed upon.

Right: Often called the long-tailed field mouse, the wood mouse lives in fields, woods and almost all areas with sufficient low cover of vegetation.

grassland and farmland
hedgehog
mole
common shrew
rabbit
brown hare
field vole
harvest mouse
weasel
fox
badger

rivers and wetland
water shrew
water vole
otter

heathland and sand dunes
pygmy shrew
rabbit

seashore
otter

pygmy shrew
water shrew
horseshoe bat
pipistrelle bat
bank vole
water vole
wood mouse
stoat
fallow deer

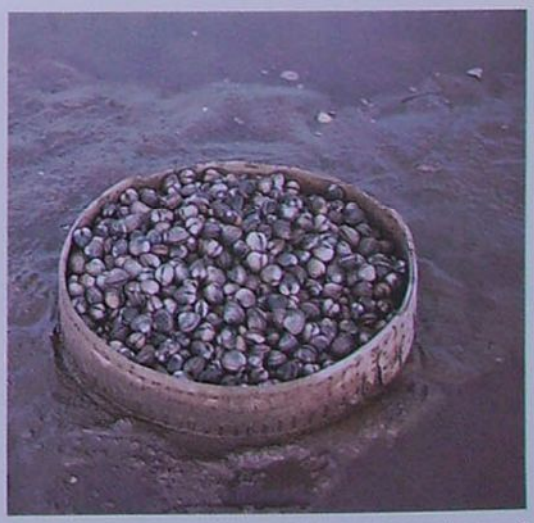
pipistrelle bat

hedgehog
mole
common shrew
field vole
wood mouse
harvest mouse
stoat
weasel
fox

water shrew

COMMON COCKLES: TASTY SEAFOOD

The shellfish industry harvests thousands of tonnes of cockles a year from our coasts, but man is far from being the only consumer: wading birds, gulls, starfishes, crabs, flounders and plaice are among our rivals in exploiting this nourishing food.



There is probably no more familiar shellfish than the cockle; millions of cockles form extensive, crowded beds in many sandy estuaries around our coasts. They are also tasty eating and are sold at many seaside towns after they have been boiled and the meat extracted from the shell.

The common cockle Several species of this bivalve mollusc occur around Europe, many of which live offshore, but the common or edible cockle (*Cerastoderma edule*), found in Britain, is a true shore animal living between mid-tide and low water levels. Common on sandy beaches, cockles also inhabit a wide variety of substrates ranging from soft mud to stony gravel. In these areas cockles can be found buried just under the surface; they sometimes occur in immense numbers with densities exceeding perhaps a thousand per square metre.

When the cockle bed is covered with water at high tide the animal lies buried in the sand with its siphons (tubes for water intake and exit) projecting just above the surface of the sea-bed. A continuous current of water enters the shell cavity and nourishment is obtained from the microscopic plants (diatoms and flagellates), plant debris and a few very small animals filtered out of the water and trapped on the gills of the cockle.

Annual 'growth rings' on the outside of the shell indicate the age of an individual cockle,

Above: The traditional way of harvesting cockles is still in use on the sands of the Burry Inlet between the Gower Peninsula and the mainland of South Wales. The harvester digs up a spadeful of sand filled with cockles and places it in a round sieve with which he separates out the fully grown cockles from the sand and any undersized specimens. Cockles of the right size, seen close up in the lower picture, are placed in sacks and loaded on to the waiting cart.

and from these it is known that cockles can live for more than ten years. On beds exploited by fishermen the life span is reduced to around four or five years. At about two or three years of age cockles reach the size at which they are commercially fished.

Breeding and settling Cockles reach maturity and begin to spawn when they are about one year old. Cockles are either male or female, though there is no obvious external difference between the sexes. Spawning occurs in the spring but may continue into the early summer. At the time of spawning, eggs from the female and sperm from the male are shed in vast numbers into the water, where fertilisation and development of the eggs take place.

The eggs hatch into minute larvae which float around in the sea for about three weeks, developing as they grow. When the larvae reach a size of about 1mm they settle to the sea-bed and are then known as cockle spat. At this small size they do not burrow into the sand but as they grow the young cockles use their muscular feet to dig into the sand and remain in a suitable place.

Although the life history of the cockle has been studied in great detail it is still not known whether the young cockles can select the places where they settle or whether they are moved passively by the tides and currents. The density in which they settle in any particular place (the spatfall) varies from year to year, as does the proportion that survives to attain full size. Both these quantities are influenced by changes in the substrate, tidal conditions and the availability of suitable food at the time of spawning and settling.

Numerous predators Cockles form the food of many shore animals. Since the cockle lives in large numbers on exposed beaches it suffers from the attacks of marine predators at high tide and terrestrial ones at low tide. Fishes, such as flounders and plaice, and crabs and starfishes all feed on cockles. When the cockle beds are exposed birds–notably waders, gulls and even crows–find cockles a succulent food.

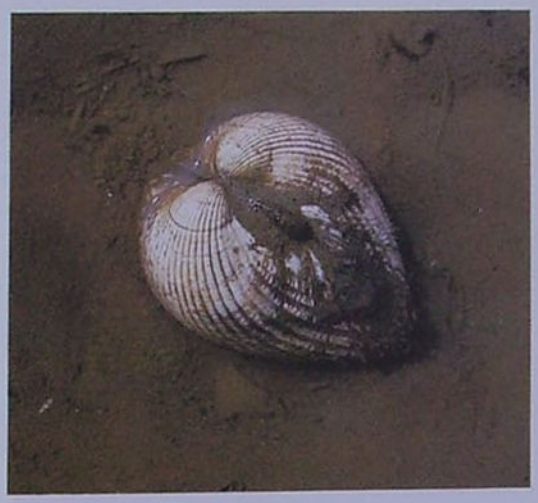
Certain waders, such as the oystercatcher, can cause considerable damage to cockle beds, especially in areas where huge flocks overwinter in Britain. A single oystercatcher is known to be able to consume up to 500 cockles in one day, though this total is unusual.

Starfishes also feed on cockles; the common starfish (*Asterias rubens*) is often seen enveloping this bivalve in its five rays, forcing the shells apart so that it can eat the soft tissues of its victims.

Harvesting methods The methods used to harvest cockles vary around the country. In the Burry Inlet, South Wales, regulations restrict the use of mechanical vehicles on the cockle beds and the gatherers use horses and carts for transportation. The cockles are hand raked out of the sand into piles which are then sieved to allow the small cockles to return to the beds. The commercial-sized cockles are then put into hundredweight sacks containing roughly 51kg (112lb) and loaded on the carts for transport to the boiling sheds for washing and cooking.

In the Thames Estuary the cockle fishery includes extensive sandflats between the Essex and Kent coasts. Boats fitted with modern hydraulic cockle dredges exploit the stocks working out of the Essex ports of Leigh-on-Sea and Southend. This dredge continuously removes cockles from the sea-bed by simply pumping sea water, sand and cockles all up on to the deck of the vessel for sieving and packing. Catch rates are high, but although this mechanical method of harvesting the Thames has been used since 1971 there is no evidence yet that the beds have been over-exploited.

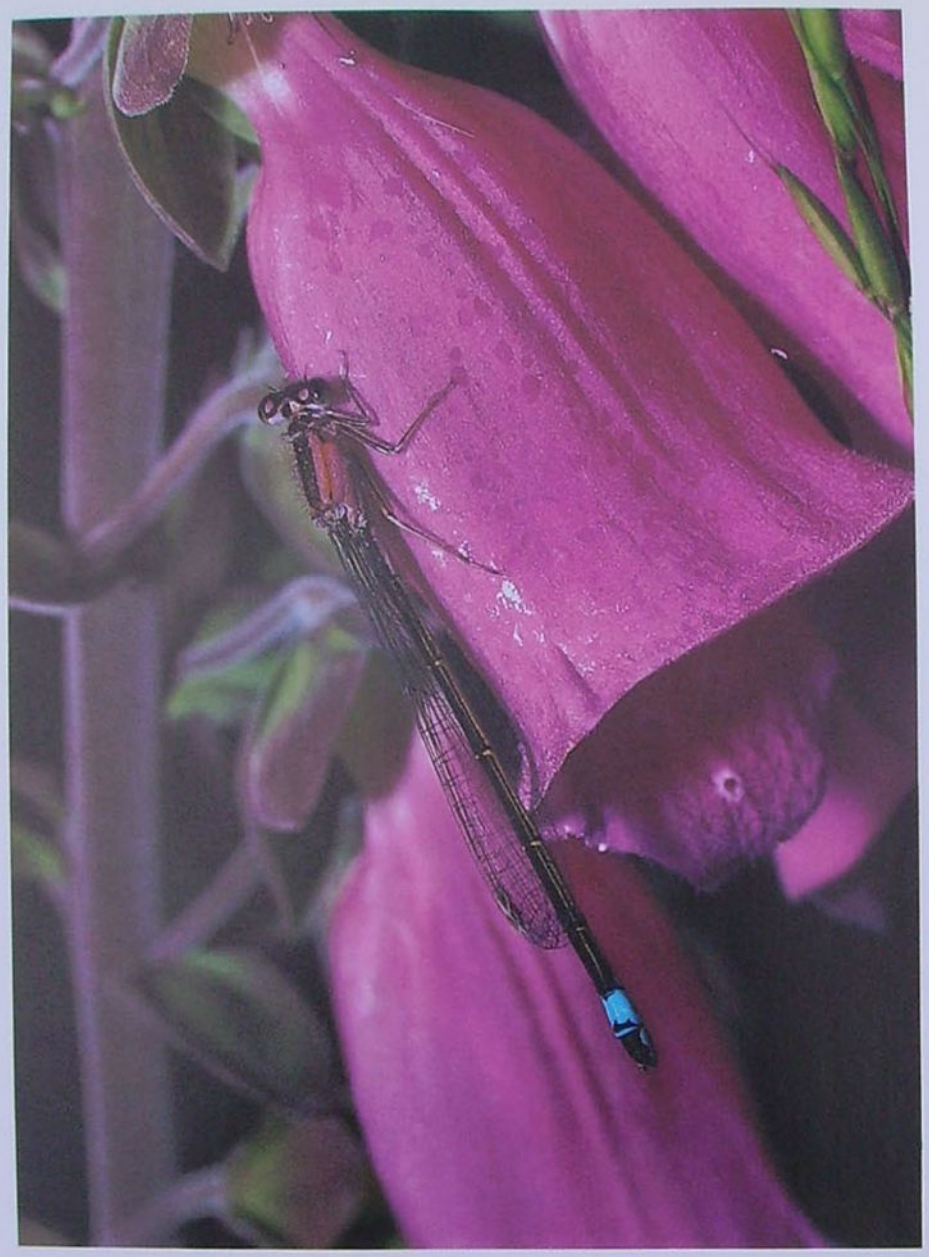
Marketing cockles Most of the cockles sold in this country are heat processed and the meats are then sold freshly cooked or preserved by freezing or pickling in vinegar or brine. Cockle meats are sold plentifully in shops and from street stalls and barrows in the fishing areas themselves, and each of the fishing areas also has its own inland marketing areas. In South Wales, street vendors or 'cockle ladies' are a feature of many of the valley towns, most of their wares coming from the Burry Inlet. Large quantities of these cockles are also sent to Bristol and the Midlands.



Above: Oystercatchers use their long beaks to pick cockles out of the sand and then to carry them to a selected patch of harder sand. There they break open the shells with their beaks to eat the soft body flesh. This activity results in pieces of broken cockle shells called 'feeding piles', seen here.

Left: A cockle lies with its foot downwards: here the brown ligament that links the two valves of the shell is visible on top.

Cockle beds
The dots mark the main commercialised cockle beds in Britain and Ireland. In Scotland large beds remain that have not been fully exploited, in the Hebrides and the Firth of Clyde. In England, the cockle industry is already at its maximum level of exploitation, providing employment for some hundreds of people in seaside towns.



INSECTS OF THE WATERY JUNGLE

Beneath the surface of our freshwater lakes, streams and rivers exists a watery jungle in which predatory insects stalk their herbivorous cousins.

Above: Many insects of ponds and streams pass their adult stage out of water. One such is the blue-tailed damselfly (*Ischnura elegans*) the adult of which bears no resemblance to its dull brown, water-dwelling larva. The airborne stage of the damselfly's life allows the adult to spread its eggs to other ponds and streams.

A remarkable variety of insects have become adapted to life in the water or on its surface, some browsing on aquatic plants while others are predators on the browsers. The vegetarian insects are often present in great numbers, far more than their predatory adversaries. However, it is important to note that the distinction between predators and vegetarians is often blurred among aquatic insects: for example, the larva of one species might be a predator while the adult is a vegetarian, or *vice versa*.

The struggle for life in water involves different insects in four main habitats within the pond or stream: the surface, just below the surface, the open water and the bed of the pond or stream. Each habitat has its own community of predators and vegetarians, each adapted to the particular problems of its chosen niche.

Surface life The surface of the water collects floating debris, such as pollen grains, dead insects and leaves, that provides food for a variety of insects. This plant material attracts large congregations of the most primitive of insects–springtails. There are two British species which have adapted to life on the water, the most common of the two being the tiny (1.5mm) *Podura aquatica*–seen with the naked eye as blue-black clusters of creatures which leap about on the surface of stagnant waters when disturbed.

Along with the bodies of dead insects these springtails are preyed upon by a whole host of bugs and beetles. These include the water-crickets and pond skaters, both of which belong to the bug order, Hemiptera, despite their common names. As with all bugs these surface dwellers have piercing mouthparts with which they suck the juices of their prey.

A common surface predator is the whirligig beetle which feeds upon small insects that fall on to the water surface. Unlike the predatory bugs, the whirligig beetle can dive for food beneath the water surface.

Under the film Living just below the surface film of still water are the vegetarian larvae of some species of biting midges and non-biting midges. These feed on algae and decaying

Right: Among the insects that pass their adult, as well as larval stage in water is the great diving beetle (*Dytiscus marginalis*). A good swimmer, aided by its powerful paddle-like hindlegs, this species is one of the largest and most ferocious of aquatic insects.

Encounters in the water

A great diving beetle larva *(Dytiscus marginalis)* capturing a mosquito larva.

A dragonfly nymph *(Cordulia aenea)*, with mask extended, attacking a phantom midge larva.

Once on the water surface many insects like this mayfly nymph fall prey to the water skater *(Gerris)*.

plant material, respectively. Living plants also provide food for some aquatic beetle larvae and at least one group of moth caterpillars called china-mark moths. The larvae of reed beetles–long, narrow beetles with brilliant metallic sheens–feed on submerged plants and obtain their oxygen supplies by tapping into the air spaces of their foodplant. The caterpillars of china-mark moths live inside protective cases made from fragments of the floating leaves of water plants beneath which they feed.

Life is hazardous close to the surface, as many of the larger insect predators regularly rise to the surface to replenish their air supply, and may take a quick meal at the same time. Species such as the water boatman and the great diving beetle would find easy pickings among the herbivorous larvae that they see on the leaves of surface plants.

Open water Many of the insect predators are found swimming in the areas of open water. Among the more prominent are the water beetles; these include some of the largest aquatic insects. Among these are the fearsome *Dytiscus* species, commonest and largest of which is the great diving beetle (*Dytiscus marginalis*) with a length of 3-5cm (1½in). It attacks other aquatic creatures, including small fish and tadpoles as well as virtually any other insect it encounters.

Equally ferocious are the greater water boatmen of which we have four species in Britain. These large bugs, some 15mm long, often take on insects, and even fishes, bigger than themselves. They subdue their prey by injecting them with a poison.

Other predators of open water include the smaller beetles such as *Hydrobius fuscipes* and *Acilius sulcatus*, and species belonging to the genera *Agabus* and *Hydroporus*. All these are much smaller than the great diving beetles and

Right: The predatory water scorpion (*Nepa cinerea*) owes its name to its large grasping forelegs and its long breathing siphon, which is often mistaken for a sting.

Below: Another common bug of ponds and streams is the greater water boatman (*Notonecta glauca*). Both it and the water scorpion have a sharp pointed proboscis which they use to suck their prey dry of their body fluids.

Above: Dragonfly larvae have an unusual mask-like set of jaws hinged to the underside of their head. These can be shot out with amazing speed to capture suitable victims, such as insects, small fishes, tadpoles or (above right) young newts.

Left: The water stick insect (*Ranatra linearis*) resembles a thin version of the water scorpion–it has the same grasping forelegs and long breathing siphon.

Below: The great silver water beetle (*Hydrophilus piceus*) is mainly vegetarian in the adult state yet a carnivore as a larva.

take proportionately smaller prey. A popular item of prey for these beetles are the larvae of flies such as non-biting midges and phantom midges. The adult screech beetle is one of the more interesting species which seek out other insect larvae in open water. It owes its name to the ability of the adult beetle to squeak loudly when disturbed.

Life on the bed By far the most prolific place to live for many vegetarians and predators alike is the bed of the stream or pond. Here are found a whole range of water plants and a rich supply of organic silt and debris to form a basis for a food chain.

This is where the larval, or nymphal, stages of most aquatic insects live and feed. All face the problem of how to obtain oxygen without continually moving up to the surface to replenish stores. Most overcome this problem by possessing gills which allow oxygen from the water to diffuse into the insect. However, not all species live in oxygen- rich water; some larvae, especially those of flies, live in muddy deoxygenated places in stagnant ponds and ditches. The larvae of some species of non-biting midges overcome this problem by extracting oxygen from their surroundings and then storing it by means of haemoglobin in their bodies. The so called rat-tailed maggots–larvae of hoverflies such as *Eristalis* or *Helophilus*–have snorkel-like siphons which can extend up to 15cm (6in) to reach the water surface and air.

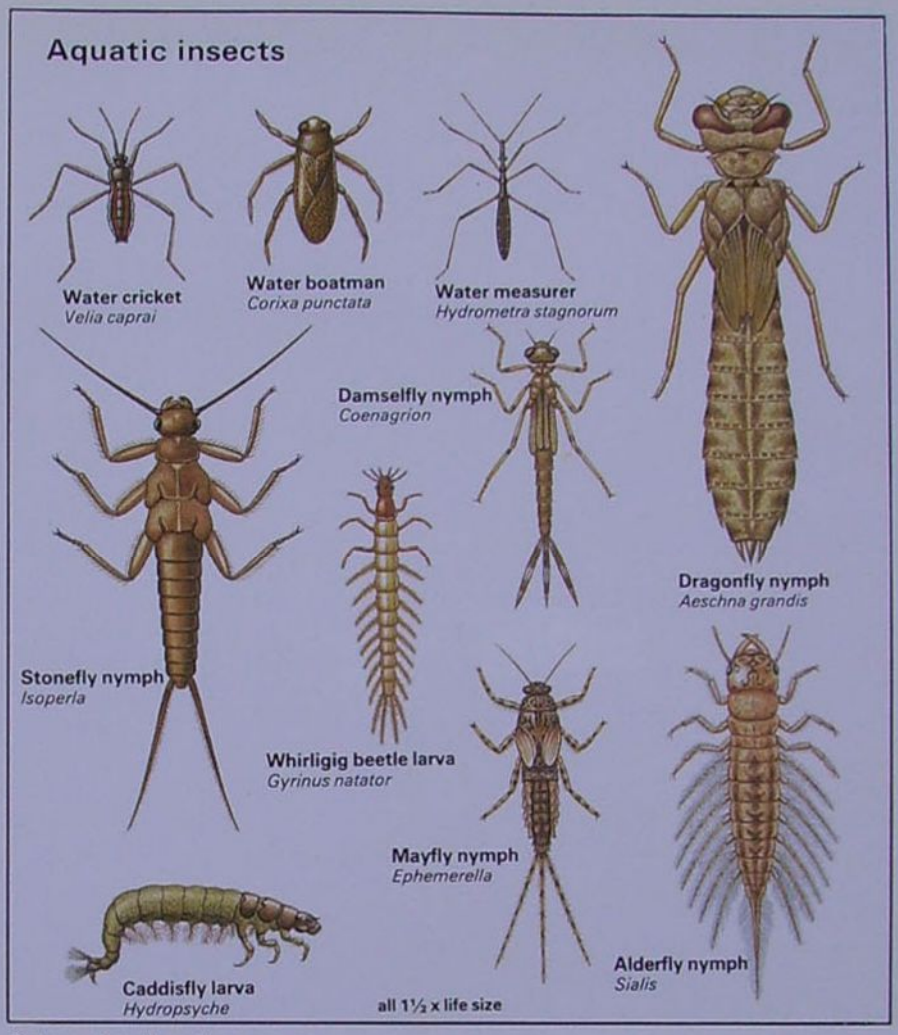
Although some species of mayfly and stonefly nymphs are carnivorous, most are vegetarian and eat fragments of plants. The mayfly nymphs may live anything from a few months to three years, depending upon the species, before reaching adulthood. Stonefly nymphs, also known as 'creepers', especially to fishermen, live for one to three years before becoming adult. Nymphs of these two insect groups are often abundant in streams and ponds and provide a rich source of food for other insects, fish and even birds such as the dipper.

Every stretch of standing or running water holds at least one species of caddisfly whose larvae usually conceal themselves in protective cases of sticks, gravel, leaves or even

snail shells. Most species browse on living and dead plant material although some, such as *Hydropsyche angustipennis*, do not build cases but trap small animals in a net. To do this they pick a stone in a fast-flowing stream and underneath it they spin a web of silk with the opening facing upstream. This behaviour is typical of aquatic insect groups–some are vegetarian while others specialise in eating smaller creatures, insect or otherwise.

Aquatic tigers The most abundant of bed and plant dwelling insect predators are the larvae of water beetles. Just as the adult beetles rule the open waters, so the larval stages are the 'tigers' of the pond-bed. Even species such as the great silver water beetle whose adult is a vegetarian have predatory larvae with sharp curving jaws with which they feed on water snails. But the most ferocious of all the water beetle larvae is that of the great diving beetle, which may grow to 5cm (2in) in length. With their powerful jaws these larvae can overpower other animals as large, or even larger than themselves. Some water beetle larvae appear to specialise in one sort of prey–that of the great silver water beetle seems to prefer water snails, while the larva of the screech beetle feeds almost exclusively upon *Tubifex* worms which it seeks in the mud.

Patient bugs In contrast to the energetic water boatmen or pond skaters many bugs use the strategy of waiting for a meal to come to them. The water scorpion (*Nepa cinerea*) can grow to a length of 3cm (1¼in) and has a long spiny 'tail' through which it obtains oxygen by pushing it above the water surface. These bugs sit among water plants and rely upon their mottled brown camouflage to blend into the background. Any suitable sized insect, fish or other small creature that comes within striking distance of the water scorpion's menacing forelegs is grabbed and sucked dry.



Below: An abundant source of food for predators in summer is mosquito larvae, which hang down from the underside of the water surface. These larvae have vibrating bristles around their mouths to trap food.

A similar but longer and more slender bug which uses the same strategy is the water stick insect (*Ranatra linearis*). Unlike the water scorpion this bug is not totally reliant upon stealth as it can swim well and is capable of flight.

About 6.5cm (2½in) in length, the water stick insect has long thin legs. The forelegs are used for grasping their prey, which consists of much the same species as the water scorpion feeds on.

Beauty and the beast Rivalling the great diving beetles as the tigers of the watery jungle are the larvae of the dragonflies and their smaller relations the damselflies. These are both stalkers which rely upon stealth and patience to grab suitable prey in their extendible jaws, or 'mask'. Once caught in the pincer-like grip the prey is pulled back under the larva's head and eaten.

The adult and larval dragonflies not only exploit different food sources, just as their land-dwelling counterparts do, but they also live in different environments. This is an important strategy allowing insects to diversify and colonize a wide range of habitats. Few insects show this better than the dragonflies–the contrast between the ugly functional larva and the sleek sparkling adult is almost unparalleled in the insect world.

Above: Lough Macnean, in Fermanagh, is one of the many loughs in the Erne river basin. The rare Cornish heath grows on the slopes to the north of this lough.

THE WINDING BANKS OF THE RIVER ERNE

The maze of water, the small rounded hills known locally as drumlins, and the natural broad-leaved woodland give the region drained by the River Erne–some 4000sq km (1500sq miles) in north-west Ireland–a special character which has impressed naturalists and visitors for centuries.

Below: A snipe sitting on its nest. The wetland meadows in the Erne basin are ideal for such birds, which probe the mud along the lough margins with their long beaks for prey.

The rivers and loughs of the Erne drain a large area in the north of Ireland, their catchment extending through as many as six counties. The largest loughs–Upper and Lower Loughs Erne–lie in County Fermanagh with Lower Lough Erne, an almost triangular lough, being the deepest in Ireland at 64m (210ft).

Watery landscape Water is the essence of this land. The ancient seas and lakes that once covered the area deposited the sediments which formed the limestone and sandstone of the mountains that straddle the River Erne. The highest point is Cuilcagh (670m/2200ft high), a flat-topped limestone mountain, capped with harder millstone grit. Over many millions of years, more water, seeping through cracks in the limestone, has dissolved the rock, leaving a network of caves tunnelling

through the mountain. In places, the caves have collapsed, creating gaping holes that have their own fascinating flora and fauna.

In more recent epochs, great sheets of ice covered this land and, as they melted, small hills of clay and gravel were left behind. These hills are called drumlins; they swarm across the Erne basin and impart to the area the characteristic 'basket of eggs' landscape.

Now, water lies in the poorly drained hollows between the drumlins, or flows sluggishly in streams around the hillocks. Partly drowned drumlins form islands in the larger loughs. The clay of the drumlins supports good pasture, so the main landuse in the Erne basin is dairy and beef farming.

Although the most distant parts of the Erne catchment are as far from the ocean as it is possible to be in Ireland, the climate is generally moist and mild. Warm, westerly winds keep severe frost and snow at bay, and bring plenty of rain–the annual rainfall is about 1300mm (50in).

Island woods Folklore says that there are 365 islands in Upper and Lower Loughs Erne, but in reality there are only about 250. Like the surrounding mainland, many of the large islands are farmed, but the smaller more inaccessible ones retain natural woodlands, some of which are now preserved as nature reserves. The dominant tree is sessile oak, but ash is also common and hazel, holly and yew are frequent in the understorey.

In the spring, the woodland floors are carpeted with bluebells, wood anemones, primroses, wild garlic and strawberries. Watermint and grass of Parnassus are also common along the lough shores.

Mainland woods On the mainland, most of the natural woods were cut down centuries ago and replaced by grassland. Here, in the drier pastures, cowslips are still abundant. In a few places, on steep rock-strewn hillsides and in sheltered river valleys, natural forest has survived. One of the best examples is in the Correl Glen Nature Reserve. This lies in a sandstone area, so the soil is peaty, without lime. Exposed, heather-covered moorland gives way to birch scrub and then, in the most sheltered parts of the valley, to oak woodland. Holly and rowan are common, too.

The ground flora includes wood sorrel, bilberry, woodrush and ferns. The moist habitat is excellent for mosses and liverworts; they clothe the trunks and branches of the oaks and in turn provide root-holds for other plants. The trees themselves become gardens, festooned with ivy, polypody ferns, wood sorrel and the occasional bluebell.

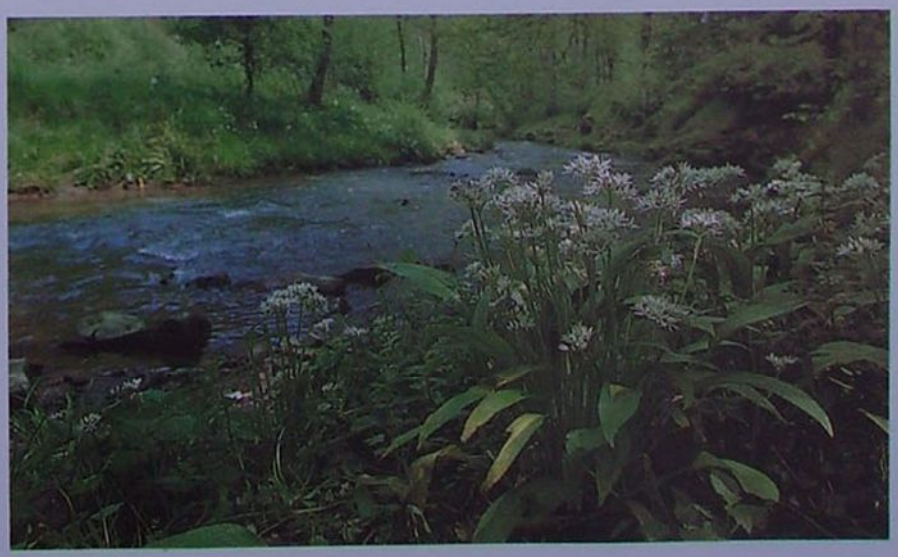
Mysterious Cornish heath On the high hills, where the underlying rock is not limestone but there are extensive moors, the blanket peat is dominated by ling and cross-leaved heath, and sedges, bog cotton and purple moorgrass also abound.

One of the most perplexing plants in this region is the Cornish heath; a small colony of about 500 plants grows on the south-western slope of Belmore Mountain. There is no other wild population of this heather in Ireland, and its nearest station is on the Lizard in Cornwall. In Ireland all the plants have white flowers, while in Cornwall the colour ranges from deep pink to white. As yet, no satisfactory explanation has been offered for why Cornish heath grows on this isolated hillside, so far from its southern haunts.

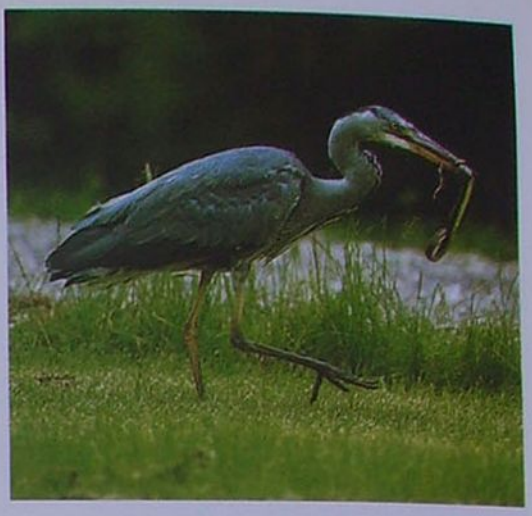
Above: The pastures of the Erne basin are bordered with hedgerows where honeysuckle grows, climbing and twisting itself around other hedgerow shrubs, such as blackthorn and hawthorn. Its flowers come out in the summer, their sweet aroma filling the country air on warm evenings.

Flora of water meadows It is said that for half of the year Lough Erne is in Fermanagh and for the other half, Fermanagh is in Lough Erne! Until modern drainage works, including a hydro-electric dam at Ballyshannon, were constructed, the Erne did flood every winter, inundating the low lying fens and marshy meadows. Even with modern flood controls, some areas are still flooded.

These wetland habitats contain numerous plants, typical of lake margins and fens. Bulrushes and reeds grow in the shallow water, while yellow water-lilies thrive in the deeper water of the sluggish streams and small loughs. The rushes and reeds also invade the water meadows, where they grow with purple loosestrife, meadowsweet and ragged robin, as well as marsh marigolds and wild iris. The Erne basin is an excellent habitat for horse-



Below: In spring the less attractive smell of wild garlic (known as ramsons in parts of England) pervades the woods on some of the islands. You may come across bluebells, wood anemones, and primroses flowering among the garlic at this time of year.



tails–all the horsetails recorded in Ireland grow here.

Wetland and water birds The rushy meadows are important habitats for birds, especially those which probe for their food–curlews, lapwings and snipe. Until recent years, one of the joys of summer was the constant chorus of corncrakes. But this bird has become so rare in the past decade that its creaking song no longer echoes over the Erne. It does nest in one or two places but is not abundant. Even rarer is the bittern, which is now just an occasional winter visitor though its relative, the grey heron, is thankfully not on the decline.

Lower Lough Erne supports a breeding colony of the scoter, a small, dull brown duck which usually breeds in coastal habitats. About 60 pairs live on the lough, and their nesting areas are protected in several nature reserves. Three species of tern, the most abundant being the Sandwich tern, also nest here on gravel islands. Mute swans nest within the town of Enniskillen and Bewick and whooper swans are regular winter visitors.

The Irish subspecies of the dipper lives by the fast-flowing mountain streams. It plunges below the water to catch insects and then bobs out again, tripping from stone to stone.

Fishes of the Erne The herons, terns and cormorants that fish in the Erne have an abundant supply of food. Another folktale says that Lough Erne is only half full of water –the other half is fish. Eel, pike, rudd, perch and bream are native and abundant. Pike can grow very large–a 27kg (60lb) fish is the largest recorded. Another plentiful fish is the native brown trout, and individuals weighing 6kg (14lb) are not uncommon.

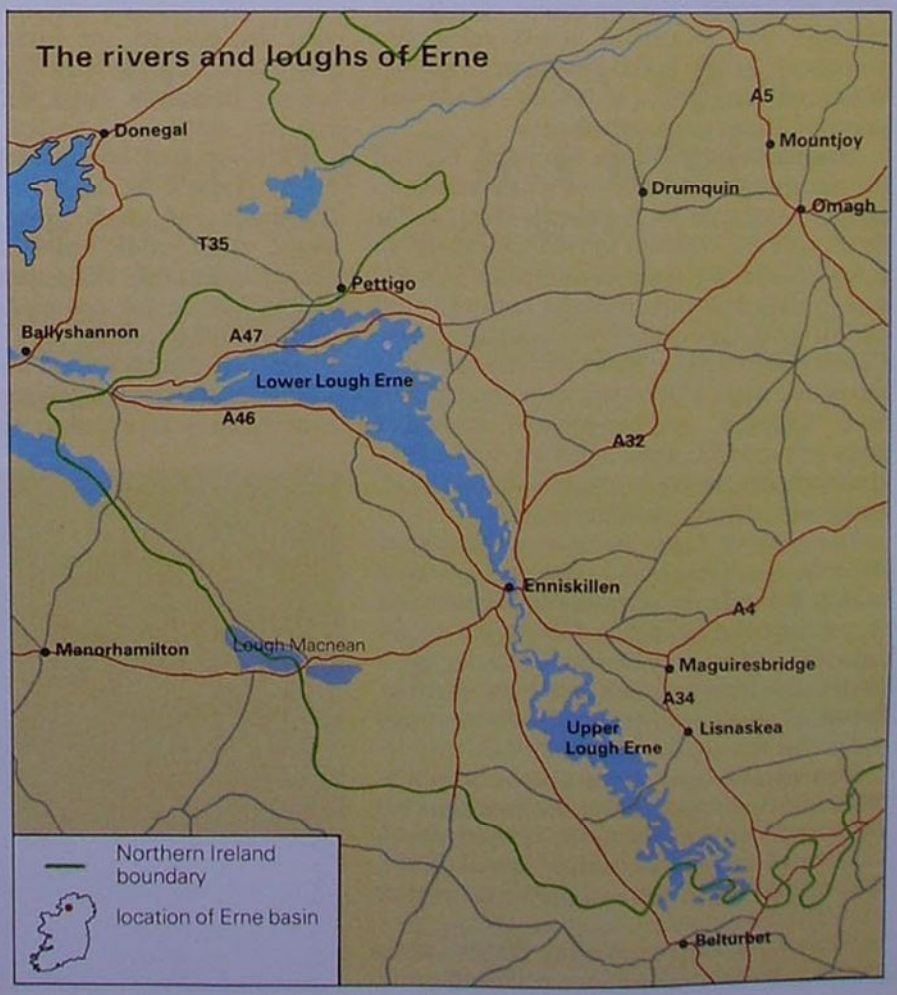
Perhaps the most interesting fishes in the Erne are charr and pollan, for they both differ from the British fishes sufficiently for some zoologists to consider them distinct species. But most now regard them as isolated local races.

Mammal life The Erne basin is still inhabited by otters. They are not as common as they used to be, but in quiet backwaters these marvellous creatures can be glimpsed. Another mammal with a refuge here is the red squirrel–although the grey does occur, it has not ousted the native red. As the red squirrel will eat a wide range of plant seeds, including those of exotic conifers, its survival in Fermanagh seems assured.

Above: Along the banks of the loughs the sight of a heron catching prey with its sharp beak is still a common one. If the fish proves to be too big for a single mouthful the heron takes it to the shore for eating. Such is the case with the eel caught by the heron in the picture, above right.

Conflicting interests The Erne basin contains many fine wetland habitats. It is an area of outstanding beauty, but like so many beautiful places it is being exploited as a tourist playground. Years ago only wooden rowing boats plied the waterway, but now numerous powerful cruisers sail on the loughs. Sadly, this leads to a clash of interests between those who wish to promote the tourist potential of the loughs and those who wish to protect the lakeland wildlife.

Below: The Erne loughs lie just within the border of Northern Ireland, though the whole river system includes parts of the Republic.



REPTILES: DINOSAUR DESCENDANTS?

There is something primeval about the appearance of a reptile, be it a large tropical animal such as an alligator or a delicate lizard of the temperate zone, such as Britain's common lizard. Their prehistoric looks prompt us to ask how they are related to those vast ancient reptiles, the dinosaurs.

Below: Close-up of a common lizard. The scales of reptiles are localised thickenings on the outer layers of the skin and are quite different in structure from the scales of fishes. Well adapted for life on land, reptiles are able to conserve their body water. They are also able to maintain warm body temperatures by using heat from the environment, stored while basking.

The relationship between dinosaurs and today's reptiles is simple: all dinosaurs were reptiles, but they became extinct 65 million years ago, whereas today's reptiles are descended from smaller, less dramatic looking reptiles that lived alongside the dinosaurs in ancient times.

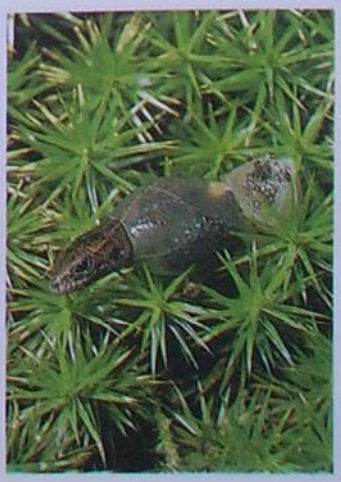
Closest living relatives? It can be argued from the above that among all animals living today, reptiles are the closest relatives of the dinosaurs, even though the line of descent is not direct. It can equally be said, however, that birds are more closely related still, for they evolved as a side-shoot of the reptilian line that eventually became the dinosaurs. It is generally estimated that the earliest dinosaurs had come into being by the time birds had evolved, so that birds are descended from the earliest dinosaurs and thus win the title in question.

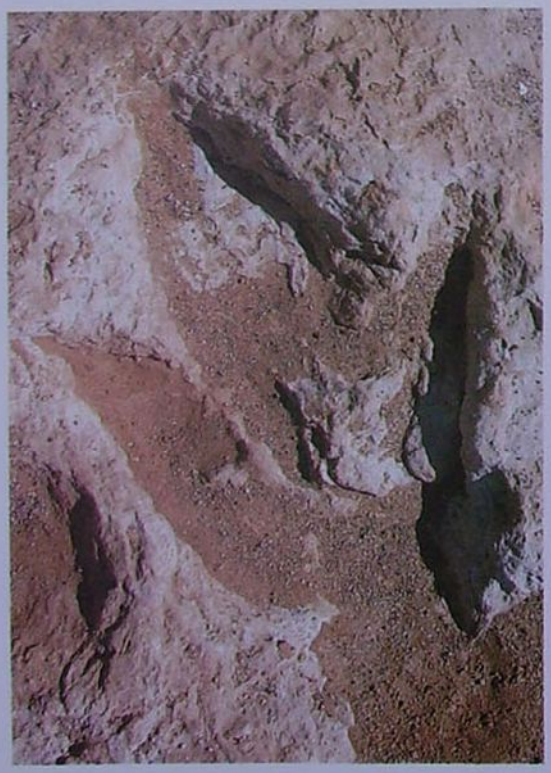
Age of the dinosaurs The dinosaurs originated in an even more ancient group of animals known as the stem reptiles. These lived in both the Carboniferous period and the Permian period (350-225 million years ago), when the continental land masses were probably incorporated into one southern super-continent called Pangaea. Later, during the Triassic period (225-190 million years ago), about a dozen major groups of reptiles evolved, one of which was the dinosaur group, which lasted through the Jurassic period (190-135 million years ago) and the Cretaceous period (135-65 million years ago).

At the end of the Cretaceous period there was a world-wide extinction of over a third of all the ancient reptiles, in which all the dinosaurs were lost. No fully plausible explanation has yet been advanced for this extinction: although in geological terms it seems a sudden event, it could have taken place over a period of 10,000 years.

Origin of the reptiles The stem reptiles had evolved from amphibians, which in turn had evolved from air-breathing fishes. The most important difference between reptiles and amphibians is the structure of the egg. The reptile egg has much more yolk, and unlike the amphibian egg it has a parchment-like shell. In addition, the developing reptile embryo is

Below: A new life begins as a common lizard hatches from its paper-thin egg. This kind of lizard is said to bear live young but, as the picture shows, the baby lizard is still enveloped in an egg for the first few moments of life.

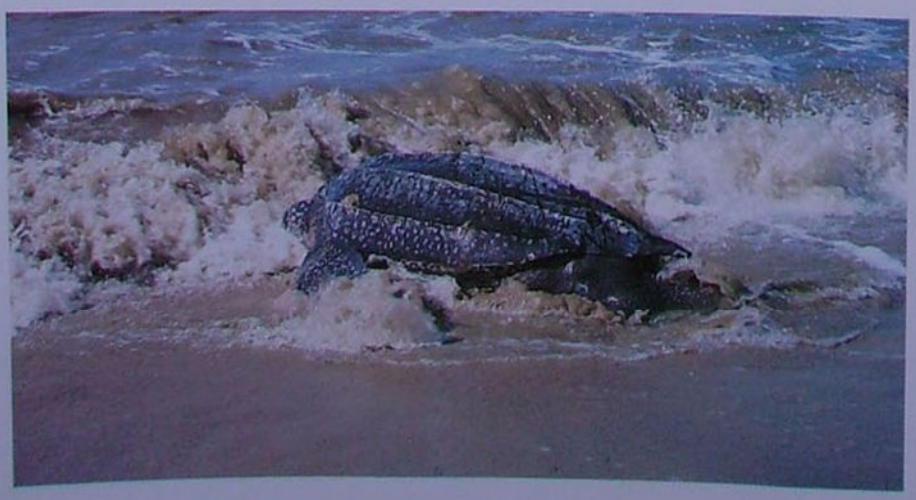




Above: A young adder. Snakes derive their great agility from a well-developed and flexible spine with many vertebrae. Most have dispensed with legs altogether, though some retain puny vestigial ones.

Left: The fossilised footprint of a dinosaur, photographed in the United States. In England, dinosaur footprints have been found in Dorset. These indicate that the large dinosaur *Iguanodon* once lived in the area. Other 'British' dinosaurs were the flying reptile *Pteranodon*, the upright walking *Megalosaurus* and an armour-plated animal called *Polycanthus*.

Below: The leatherback turtle is a living representative of a 220-million-year-old evolutionary line.



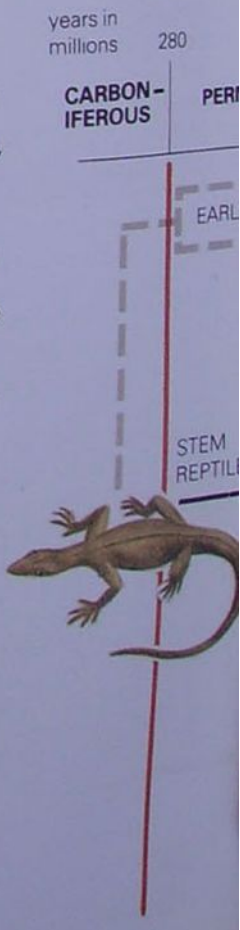
protected by three membranes and these, together with the shell, are adaptations to a life on dry land. Most reptiles lay eggs, but some give birth to live young and at birth the newborn reptile is enclosed in a thin membraneous 'shell'.

The link with birds Zoologists point out that birds are less distinct from reptiles than the layman might expect: although they seem so much more familiar to us than lizards or turtles, they are in fact specialised reptiles, the most important specialisation being flight. For this, they evolved light but strong skeletons and a high level of metabolism; and their feathers developed from the scales covering the skins of reptiles.

The link with mammals Mammals evolved from a group of mammal-like reptiles known as synapsids, and these in turn evolved from the stem reptiles during the Carboniferous period, before the earliest known birds. Many of the ancient mammals evolved and survived the age of the dinosaurs, probably because they were mostly small, nocturnal, insectivorous creatures. Evidently they were not affected by the problems that were besetting the larger reptiles of their time, and they therefore flourished at the end of the Cretaceous period in the absence of their dinosaur competitors. As they evolved they diversified into many new species and became the dominant group, a position they still hold today.

The reptile story

Reptiles have lived on Earth for 300 million years. The diagram shows that mammals originated in the earliest reptile stock, when the world's dominant terrestrial animals were the stem reptiles. Dinosaurs formed one of several ancient reptile groups that became extinct long ago. Space permits only one of the other groups to appear on this diagram–the marine reptiles, which included the plesiosaurs. Birds evolved at the dawn of the age of the dinosaurs, in the late Triassic, and in some ways they can be regarded as a successful surviving offshoot of this otherwise extinct group. Of the reptiles we know today, the oldest group is that of the turtles, tortoises and terrapins, followed by lizards and then the crocodiles and alligators. Snakes evolved last, in the Cretaceous period.



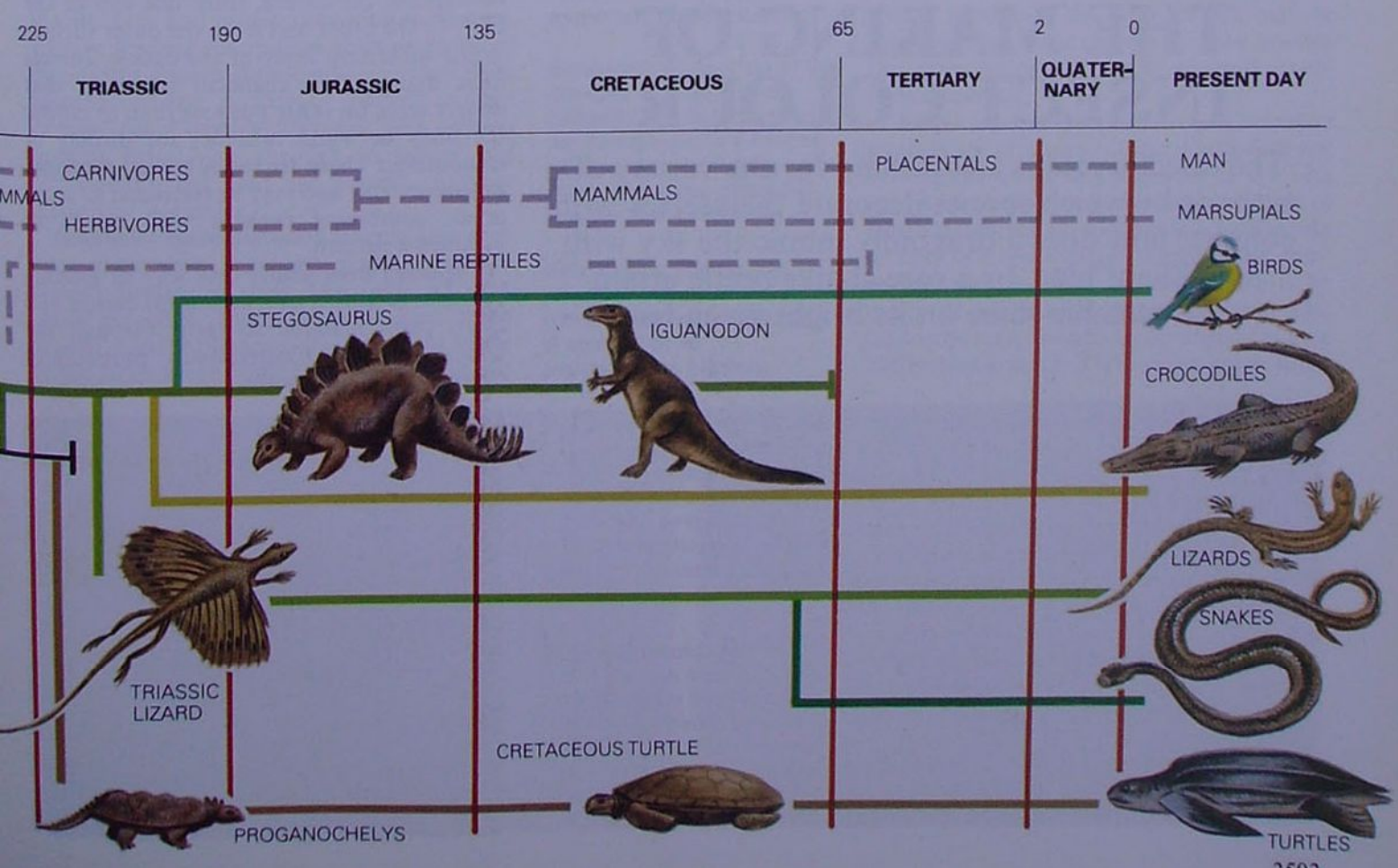
Above: The slow-worm is a legless, burrowing lizard. Although sometimes called a 'blindworm' it has keen eyesight and, like many lizards, has a 'third eye', technically known as a pineal eye, which is sensitive to solar radiation. It is located on top of the head at the mid-line, underneath the large rectangular patch on the animal's skin. This organ plays an important part in regulating the length of time the slow-worm spends basking.

Surviving reptiles Although the dinosaurs and many other reptiles became extinct, others survived and today there are over 6000 kinds worldwide. These are divided into six groups: (1) turtles, tortoises and terrapins, which have remained virtually unchanged in form for at least 100 million years; (2) a group represented by only one species living today, the tuatara of New Zealand; (3) snakes; (4) lizards; (5) a group of tropical reptiles called worm lizards; and (6) crocodiles and alligators.

Of all these six groups, lizards and snakes are by far the most abundant forms, with some 3000 and 2700 species respectively living today. One of the major lizard families is the Lacertidae, which includes the British and European genus *Lacerta*, found in fossil form dating back some 20 million years. Slow-worms belong to another family of legless lizards, the Anguidae, and fossil slow-worms about 8 million years old have been found in Europe, while much older fossils of similar families have been found in North America.

The adder, the grass snake and the rarely seen smooth snake are the only snakes found in Britain. The origin of snakes is relatively recent and it is generally believed that the loss of limbs evolved as a result of adaptations for burrowing.

Solitary survivor? In the Cretaceous period there were numerous other groups of reptiles that later became extinct. The plesiosaurs and ichthyosaurs, for example, were a spectacular group of predatory marine reptiles. Some of these reached lengths of 16m (50ft), with long, thin necks and limbs shaped like paddles. Some of the photographs reportedly showing the Loch Ness monster conjure up ideas of plesiosaurs, and in 1975 the speculative zoological name *Nessiteras rhombopteryx* was given to the creatures said to live in the waters of Loch Ness. Sadly there is no material evidence to confirm that plesiosaurs do live in Loch Ness, but it is nice to think that perhaps a near relative of the dinosaurs could possibly still survive after so many millions of years. The species would be the sole member of a seventh group of reptiles living today.



THE MAKING OF INSECT COLOUR

The insect world is astonishing for the variety of methods by which species decorate themselves with colours: how does a dragonfly mimic the sky with its brilliant blue, or a rose chafer beetle attain such a metallic shine on its bright green back?

Few groups of animals can rival the insects for variety and brilliance of colour. Each insect species has a unique colour pattern by which it can be recognised. Each colour pattern serves a purpose and to this end has been shaped and perfected by the pressures of natural selection. First and foremost, the colours of an insect are signals, directed at two main audiences: colours can warn or confuse vertebrate predators such as birds and lizards; and they contain a message for other insects–often encoded in the ultraviolet portion of the spectrum.

Some colours are essential to courtship, while others are used to conceal or, in warningly coloured insects, to threaten. However, not all colours are used solely for the communication of some biological message. For example, dark colours help some insects to absorb heat from sunlight. Those living at high altitudes, or in cold climates, are darker than their lowland relatives.

Brown and black insects Brown ants and numerous other ground dwelling insects are brown because of the tanning effects of the chemical process by which their cuticle is hardened. The young ants emerge as soft, colourless insects and as they grow to maturity their cuticle becomes progressively harder and browner. Both the hardness and the colour are properties of a substance called sclerotin, which spreads to every part of the body including the antennae and the legs. The brown colour camouflages the insect against a background of earth, bark or dead leaves.

Black beetles, ants, flies and all other insects that are totally black attain their deep colouring in a related way. The chemical that reacts with soft cuticle to produce sclerotin is often released in huge quantities, far more than is needed to harden the cuticle. Instead, the enormous excess of this hardener is converted to a pigment called melanin–the same pigment which gives us black hair and dark skin.

Chemical colours The brown and black colouring of sclerotin and melanin, though often beneficial as camouflage, is produced as a side-effect of the vitally important process of growing a tough layer of 'armour'. This is reflected in the fact that they are spread throughout the cuticle, from one end of the body to the other and from the outer surface to the innermost layer of the cuticle. Insects have many other chemical pigments that clearly serve no other purpose than to colour the body or wings, whether for display or camouflage. These are rarely spread throughout the cuticle, and may be restricted to small areas, combining perhaps with others to produce a pattern.

Pigments from plants One way of gaining colour is to keep a soft, colourless cuticle and allow plant material to show through the body wall. Some caterpillars, particularly those of noctuid moths, are green because

Above: The damselfly *Pyrrhosoma nymphula* is instantly visible with its fiery red body. This red colour is an ommochrome pigment, formed from chemicals naturally present in the body of the insect.

Right: The commonest of all insect colours is the brownish-red sclerotin: it is produced when a hardened secretion acts on the soft cuticle. Sclerotin is seen in the tough case of this privet hawk-moth pupa.

chlorophyll in their intestines, taken from the leaves they eat, shows through their body wall.

A more common strategy in insects, however, is to absorb pigments from plants and redeposit them in their own bodies. Scientists place these plant pigments in four main groups, each associated with a characteristic range of colours.

Carotenoids are red, orange and yellow plant pigments responsible for the colour of tomatoes, carrots and the fresh green colour of leaves in spring. Ladybirds use these pigments, and so does the bug *Pyrrhocoris apterus*. Xanthophylls produce bright yellow colours, and the larvae of an ichneumon wasp, *Apanteles glomeratus*, use them to colour the silk of their cocoons.

Anthocyanins are pigments that produce scarlet, blue and purple colouring in flowers. Flower feeding caterpillars such as those of pug moths absorb anthocyanins as they feed, gaining in the process a perfect colour camouflage. Fourthly, flavones give colours ranging from ivory through to yellow and occasionally red, and are present in great quantities in grasses.

Internally made pigments Insects also produce their own pigments from chemicals already present in their own cells. As with plant pigments, these fall into four main groups. Pterine pigments are seen in the white of the large white butterfly, the yellow of the brimstone and the orange of the orange-tip. The second group, the ommochromes, may be yellow, red or brown. They are prominent in the red bodies of dragonflies such as *Sympetrum striolatum* or *Pyrrhosoma nymphula*, and on the wings of the small tortoiseshell butterfly.

Aphins are typically deep blue or black internally made pigments. They are responsible for the colour of dark species of aphids, such as the black bean aphid. The fourth group are the bilins, which may be green or blue-green in colour. They provide the green colour of newly emerged chironomid midges.

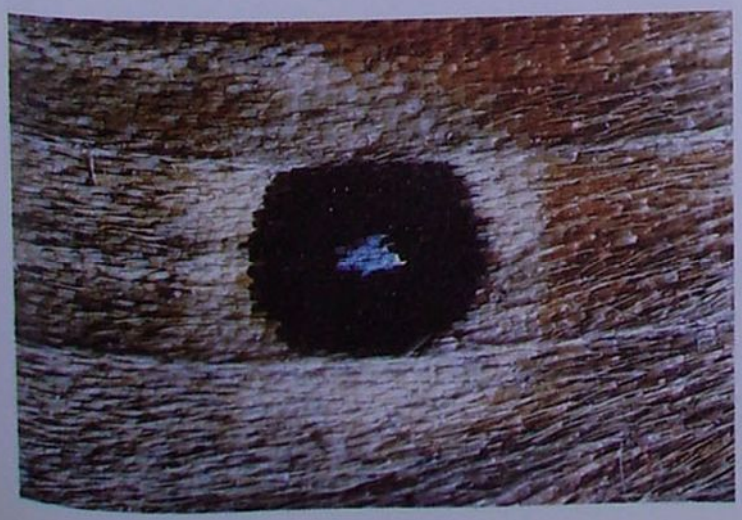
Ridged reflectors Insects have an alternative strategy for producing colour which does not involve the use of any pigments at all. This is structural colouring, the basic principle of which is to break up sunlight in a similar way to that of a glass prism. Perhaps the commonest way in which insects do this is by means of microscopic ridges on the cuticle: zoologists refer to such an arrangement as a 'diffraction grating'. These ridges are so small

Above: A close-up of the wing of an orange-tip butterfly: orange pterine pigment is deposited on the scales. Pterines are made from chemicals in the insect's body and can also be white, yellow or red.

Above left: The bloody-nose beetle is jet black with melanin, formed from an excess of cuticle hardener.

Below left: A close-up of the eye spot of a large heath butterfly. The buff colour of the background is a flavone pigment derived from grasses eaten during the caterpillar stage of the insect's life.

Below right: The orange patch on this small tortoiseshell butterfly's wing is made with an ommochrome pigment.



Above: Iridescent hues of purple and turquoise: the fly *Chloromyia formosa* is one of many that have a ridged outer surface, the effect of which is to give a different tint for every angle at which the surface is viewed. The basic bluish colour beneath the iridescence is a structural colour produced by the interference of reflected light from two or more thin layers of cuticle.

Below: The metallic green of the tiger beetle is another example of 'interference colour' resulting from the reflection of light through more than one layer of cuticle. This insect is not the shiniest of beetles, and the close-up shows the pitted and peaked surface that gives it its relatively matt finish.

that the distance between them is comparable to the wavelength of light. This has a profound effect on the way in which the insect's body reflects light: the sun's light is broken up into individual colours, and the colour that the eye perceives varies with the angle at which the insect is viewed.

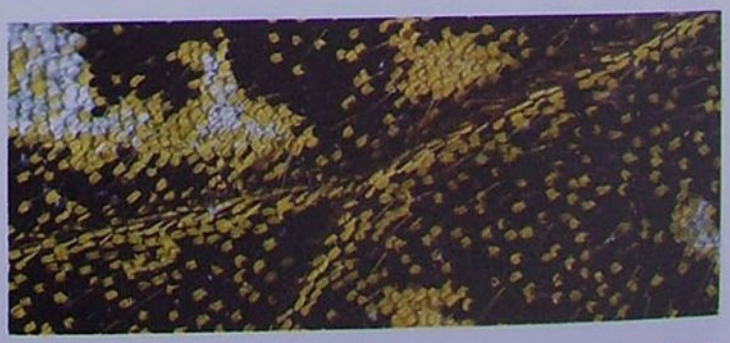
Several families of beetles, including the ground and rove beetles, possess these fine ridges. The colour effect tends to be produced only in bright light, but this is probably the time when it is most likely to help the beetle to survive: it may help to confuse predators if the beetle is caught out in an open, sunlit patch of ground. Unlike the black caused by the beetle's melanin, the reflected colours are constantly shifting and changing in intensity as the beetle moves. It is this shimmering effect (iridescence) that makes the beetle difficult to pinpoint and catch.

Smooth reflectors The shiniest of all insects are those metallic beetles such as the brilliant green rose chafer beetle. Its green colour is produced in exactly the same way as the colours of a film of oil floating on water. Sunlight is reflected off the surface of the oil, and also off the water immediately below. The two reflections 'interfere' with one another, and the result is a single colour instead of a mixture. Like the oily water surface, the cuticle of a metallic insect is made from layers, each separated from the next by air or liquid. As light strikes each layer the reflected rays from each interact to produce colours: the actual colour depends on the thickness of the layers, which in the case of the rose chafer are exactly arranged to produce that unmistakable hue of green.

Particles in the way A third form of structural colour is seen in the intense blue of dragonflies such as the broad-bodied libellula (*Libellula depressa*). Light is reflected from the lower layers of the cuticle through a suspension of tiny particles in the upper cuticle layers. The particles scatter the blue rays of the spectrum in such a way that these are the ones we most strongly perceive. The particles in the dragonfly's cuticle are doing exactly the same as the dust particles in the uppermost layers of the Earth's atmosphere, for these also scatter blue light and are the cause for the pervading blue colour of the sky. If the particles are slightly larger, they scatter white light as an opaque whiteness–producing the brilliant whiteness of clouds, and of insects such as the satin moth.

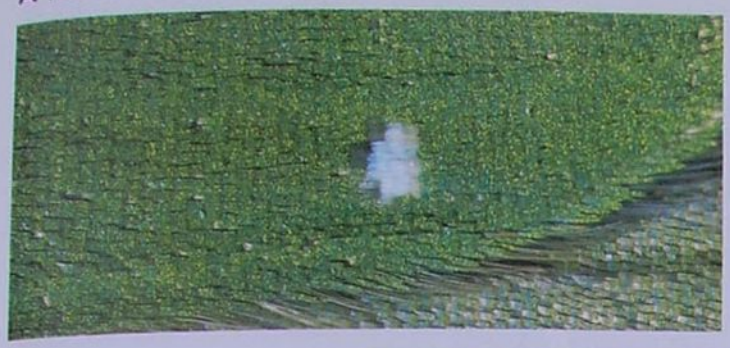
Colours in close-up

An optical illusion

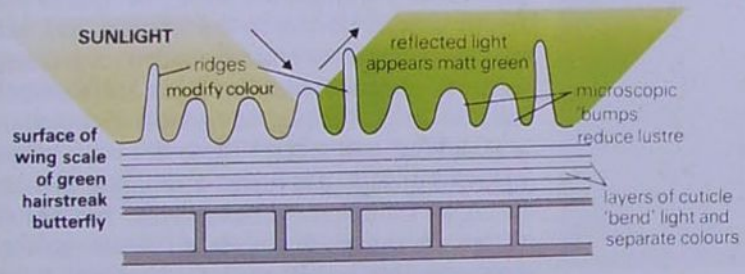


The patches of green on the underwing of the orange-tip butterfly (right) are created by deceiving the eye. The close-up of one of the green patches (above) shows that none of the scales is actually green, but the effect is created by a mixture of black and yellow pigmented scales.

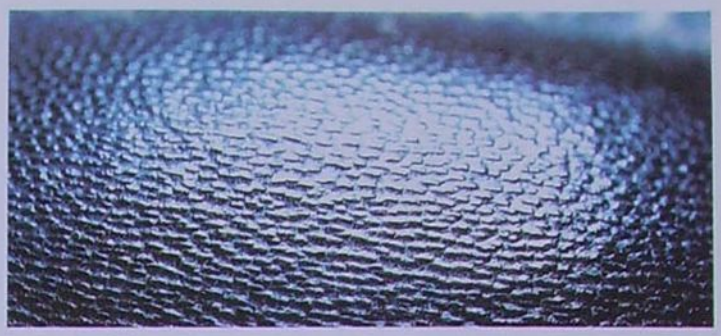
A matt metallic finish



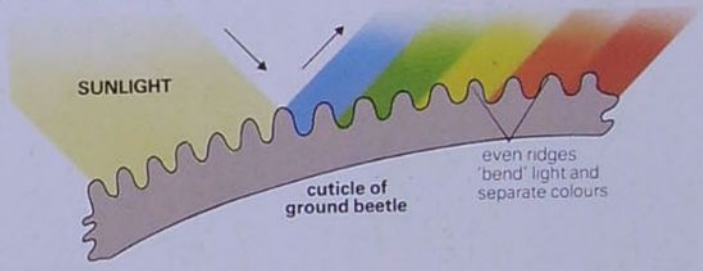
The green hairstreak butterfly (right) has an even more matt version of 'interference colour' than the tiger beetle. The surface of the scales (close-up above) is broken up by microscopic bumps (diagram below). The result is a non-reflective green giving camouflage against a background of fresh leaves in spring.



A shimmering black

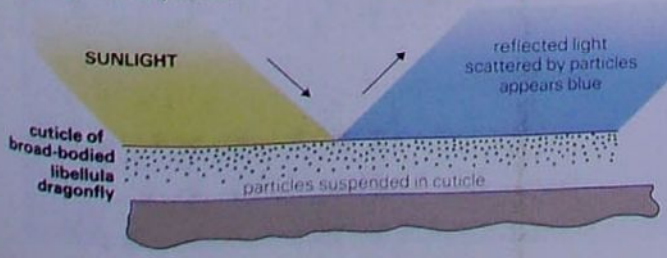


The ground beetle *Carabus violaceus* (right) is one of the many black beetles that shimmer in bright light. Each ridge in the cuticle surface (close-up above, diagram below) reflects light at its own angle. The combined effect of all the ridges is that any point on the surface changes hue with the angle of viewing.

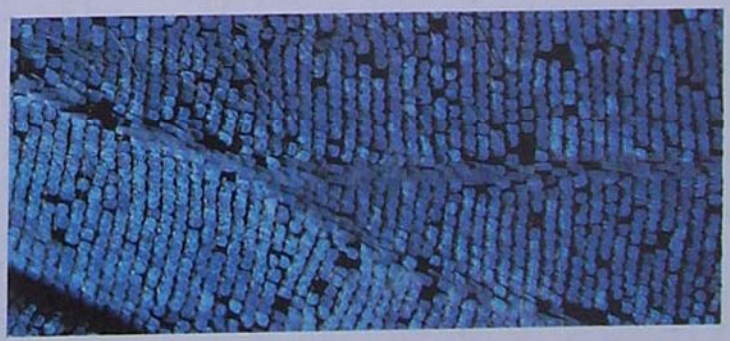


Scattering light

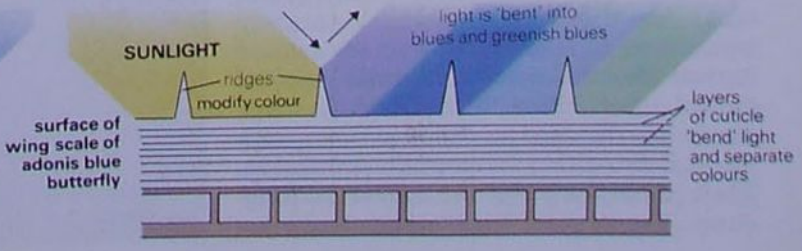
Some insects have tiny opaque particles suspended in their transparent and colourless cuticle. These scatter white light into colours (diagram below). In the pearly spots under the wing of the dark green fritillary butterfly (above) the colour is a whitish blue; on the broad-bodied libellula (right) it is sky blue.



A shimmering blue



The adonis blue (right) is an iridescent butterfly: its shimmering hues of silvery blue are interference colours produced by the reflection of light through very thin cuticle layers on the scales. Microscopic ridges on the scales add to the shimmering effect (close-up above, diagram below) and give a 'satin' finish.



BRITAIN'S PLANTS CLASSIFIED

In Britain alone there are well over 3000 species of plants, from minute algae to giant trees and delicate orchids. By classifying these species into groups the botanist manages to cast considerable light on the relationships between our plants.

We all recognise that the most fundamental way to divide living organisms is into plants and animals. Plants–at least green plants, which are the vast majority–are capable of creating their own food by means of photosynthesis. Animals, on the other hand, cannot produce their own food; instead they have actively to hunt or search for it. Even sponges, which seem most unanimal-like, actively pump water through their bodies for its food content. Biologists accept this basic division, though most add a third category, fungi, which are regarded as being distinct from plants because they cannot photosynthesise. These three categories are known as kingdoms. The Animal Kingdom is the largest with about 2,000,000 species, most being invertebrates; next comes the Plant Kingdom with about 300,000 species; and finally the Fungus Kingdom with about 120,000 species.

Above: Musk mallow in flower. Both the flowering plants and the conifers show a considerable advance over the lower plants, such as mosses and ferns, because they reproduce by means of seeds instead of spores. The advantage of seeds is that they have a built-in store of food that allows them to germinate and grow even in adverse conditions. Spores, however, have no such food store and so can only develop into a plant in ideal conditions.

Dividing the Plant Kingdom Even just a cursory look at the plants in Britain shows how diverse they can be, from huge trees to small mosses and liverworts, and from mountain flowers to marine seaweeds. All our plants are classified into various groups. The two major groups are the subkingdoms Thallobionta, which contains the algae, and Embryobionta, which contains all other plants. (Note that lichens, because of their complex nature with both fungal and algal elements, are classified separately.)

Algae are regarded as being quite different from other plants for several reasons. For example, algal plants are not divided into stems, leaves and roots (although some superficially possess these parts). Instead the whole body is said to be undifferentiated and is called a thallus. Although algae are placed in a separate subkingdom they are not particularly numerous, with just 17,500 different species known in the whole world, and many of these are single-celled organisms. Some of our most familiar algae are seaweeds, such as kelp (*Laminaria* species) and bladder wrack (*Fucus* species). These are both brown algae, a group that forms a separate division of algae called the Phaeophyta. Sea lettuce (*Ulva lactuca*) is a bright green seaweed common in small rockpools around our coasts. It belongs to another division called the Chlorophyta which, with more than 6500 species worldwide, is the largest division of the algae.

Mosses and liverworts Just as the subkingdom of algae is split into divisions, so too is the other subkingdom, the Embryobionta. One division, the Bryophyta, contains mosses and liverworts (and three species of hornwort). All remaining plants are placed in the other division, the Tracheophyta.

With mosses and liverworts we see the beginnings of a differentiation into stems and leaves (though not yet roots). There are over 600 species of moss in the British Isles and nearly 300 of liverworts. The two groups are very similar to each other, though there are differences in their reproduction and mosses are always leafy whereas many liverworts are, like algae, thallose with undifferentiated leaves and stems.

Vascular plants The other division, the Tracheophyta, contains what are known as vascular plants since they possess vessels through which water, minerals and nutrients can be conducted from one part of the plant to another. This seemingly simple (though actually highly complicated) trick allows vascular plants to grow much larger than non-vascular ones–mosses, liverworts and algae.

The vascular plants are divided into several subdivisions, the most primitive of which is the Lycophytina, the clubmosses. In Britain

Above: Carragheen, a species of red alga common around our coast. The algae are classified into a separate subkingdom from all other plants because of their primitive nature: they have no distinct leaves, stems and roots, the whole plant consisting instead of a single structure called a thallus.

Above left: Flowering rush showing the long narrow leaves typical of monocots.

Below: Mosses and liverworts share with algae the distinction of being non-vascular plants–they lack vessels via which water and nutrients can be conducted from one part of the plant to another and rely instead on diffusion from cell to cell. The liverwort shown here, *Marchantia polymorpha*, is known as a thallose liverwort because, like algae, the individual plants do not have distinct leaves and stems, the whole plant body being known as a thallus. The umbrella-like structures are female reproductive organs.

there are just eight species in this group (which bears no relation to mosses) and they are largely confined to damp habitats. With the next subdivision, roots appear for the first time. This is the Sphenophytina of which the most familiar species in Britain is the common horsetail (*Equisetum arvense*). The third subdivision is the Filicophytina, which contains the ferns, an important group of plants in the British flora with about 50 species native to our islands.

Seed plants The last subdivision of the vascular plants represented in Britain is also the most important. This is the Spermatophytina, or the seed plants. All the plants so far mentioned reproduce by means of spores. A spore consists purely of the fused male and female sex cells. Therefore, once it has been dispersed, landed in a suitable place and begun to germinate it has to be able to obtain nutrients from its surroundings straight away, or else it will die. Seeds, however, possess their own food reserves as well as the fused sex cells; consequently they are able to start growing whether or not the conditions are ideal. This gives them a great advantage over spores.

The seed plants are divided into two groups called classes: the Coniferopsida and the Angiospermopsida. The former are usually known as gymnosperms and the latter as angiosperms or flowering plants. The basic difference between these two groups is that the gymnosperms have cones in which the seeds are borne on the cone scales exposed to the air (the word gymnosperm means naked seed). Angiosperms, on the other hand, have flowers, not cones, and their seeds are protected in an ovary, which develops into a fruit.

There are only three species of native gymnosperms in Britain, and they are all conifers: the Scots pine (*Pinus sylvestris*), the yew (*Taxus baccata*) and the juniper (*Juniperus communis*).

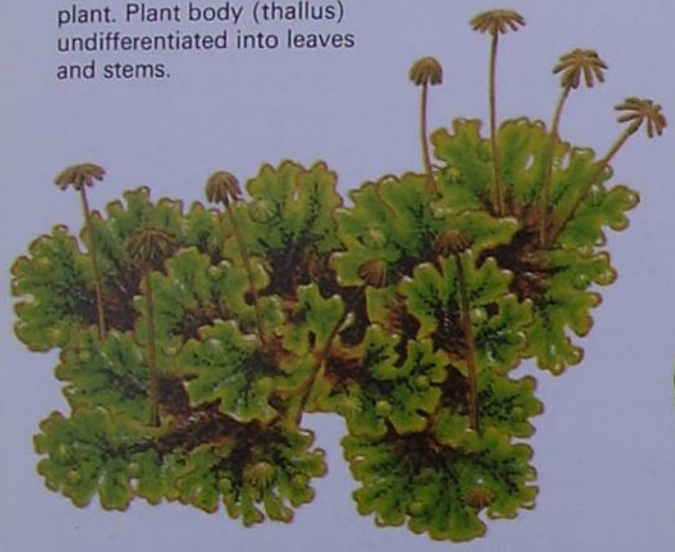
Flowering plants The angiosperms are the most familiar and important plants in Britain, including as they do all our trees, our wild flowers and vegetable and cereal crops. There are almost 150 different angiosperm families native to Britain, of which the majority belong to a subclass called the Dicotyledonidae (or just dicots for short) while the remainder belong to the Monocotyledonidae (monocots). These names refer to the number of seedling leaves (called cotyledons) that first appear after germination–in the dicots it is two and in the monocots one. But there are other differences: monocots are never truly woody (even though some, such as palms are very tree-like), their leaves are usually narrow with parallel veins, and their flowers have their parts (petals, stamens, and so on) in threes or sixes. Dicots are the opposite: many are woody, their leaves are broad with net veining and their flower parts are usually in fours or fives.

Typical didcot families include the buttercup family (Ranunculaceae), which contains many meadow flowers such as meadow-rue and the beech family (Fagaceae), which is an important family of trees that includes oak and sweet chestnut. Monocot families include grasses (Graminae), sedges (Cyperaceae), orchids (Orchidaceae) and lilies (Liliaceae). The monocots have highly specialised floral structures and pollination mechanisms.

Major plant groups

The Plant Kingdom is divided into two subkingdoms, one of which (Thallobionta) contains algae and the other (Embryobionta) contains all remaining plants. The Embryobionta consists of one division of mosses, liverworts and hornworts (Bryophyta) and another division of vascular plants (Tracheophyta). The latter, in turn, is broken down into several subdivisions, the most important of which is the Spermatophytina, the seed plants, which contains the conifers and flowering plants.

Subkingdom	Division	Subdivision
EMBRYOBIONTA	Bryophyta	Hepaticopsida (liverworts) Anthocerotopsida (hornworts) Bryopsida (mosses)
	Tracheophyta	Lycophytina (clubmosses) Sphenophytina (horsetails) Filicophytina (ferns) Spermatophytina (seed plants)



Marchantia polymorpha
Thallose liverwort. Non-vascular spore-producing plant. Plant body (thallus) undifferentiated into leaves and stems.

Silver thread moss
(*Bryum argenteum*)
Moss. Non-vascular spore-producing plant with stems and leaves. Both mosses and liverworts have spores borne in stalked cases.

Lycopodium alpinum
Clubmoss (Lycopsida). Vascular spore-producing plant. No relation of the mosses. Spore cases borne in leaf axils.

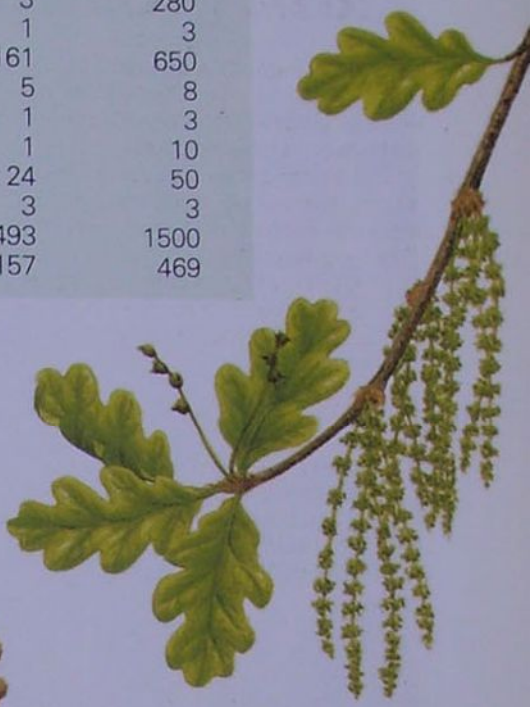
Lophocolea cuspidata
Leafy liverwort. Non-vascular spore-producing plant. Distinguished from thallose liverworts by having stems and leaves.

Isoetes lacustris
Quillwort (Isetopsida). Vascular spore-producing plant. Spore cases borne at base of leaves.

Class	Subclass	No. of British families	No. of genera	No. of species
		28	3	280
		1	1	3
		37	161	650
Lycopsida		2	5	8
Isetopsida		1	1	3
		1	1	10
		13	24	50
Coniferopsida (conifers)		2	3	3
Angiospermopsida (flowering plants)	Dicotyledonidae	120	493	1500
	Monocotyledonidae	26	157	469

Field horsetail
(*Equisetum arvense*)
Horsetail. Vascular spore-producing plant. Spores borne in cone-like structures on the ends of stems.

Scots pine
(*Pinus sylvestris*)
Conifer. Vascular seed-producing plant. Seeds borne naked, usually on cone scales. Plants usually woody.

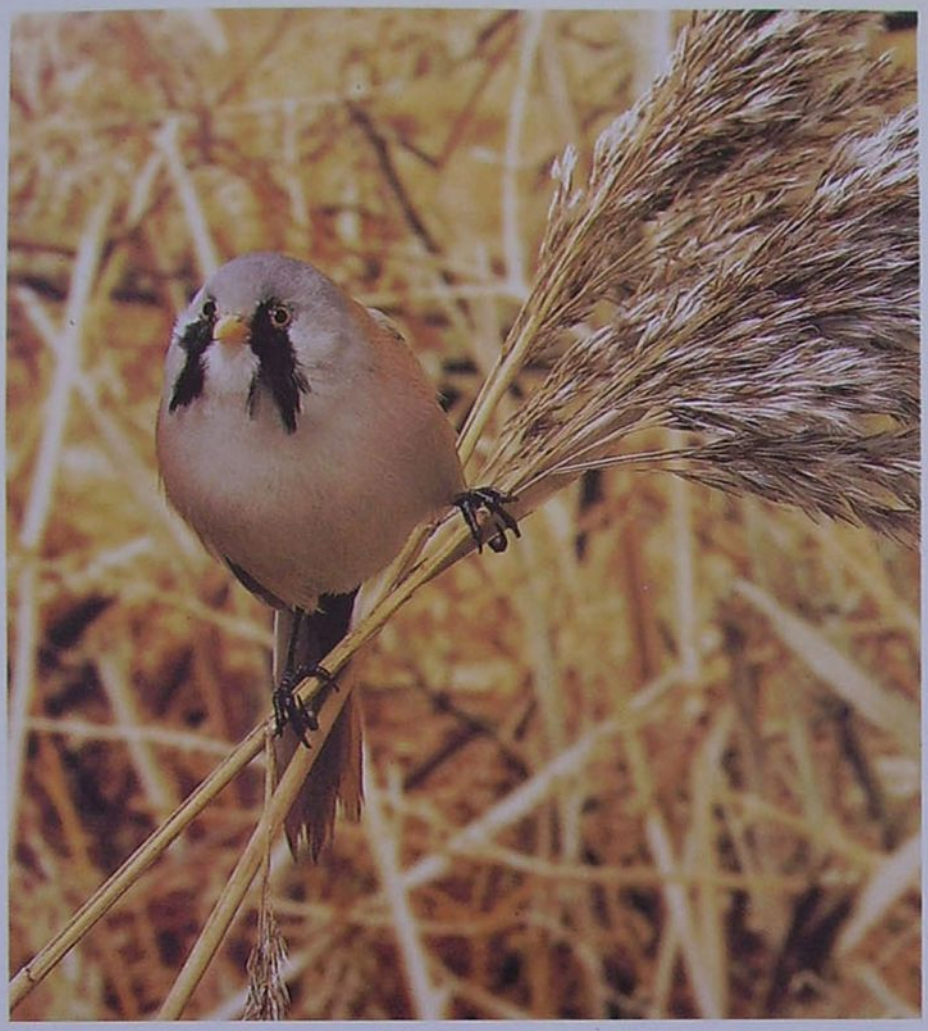


English oak
(*Quercus robur*)
Angiosperm (dicot). Features as for daisy. Dicots are the only angiosperms capable of being truly woody.

Royal fern
(*Osmundia regalis*)
Fern. Vascular spore-producing plant. Spores usually borne on the undersides of leafy fronds.

Daisy
(*Bellis perennis*)
Angiosperm (dicot). Vascular seed-producing plant. Seeds borne enclosed in an ovary. Flower parts usually 4-5; leaves broad with net veining.

Meadow saffron
(*Colchicum autumnale*)
Angiosperm (monocot). Vascular seed-producing plant. Seeds borne in an ovary. Flower parts 3 or 6; leaves narrow with parallel veining.



BEARDED TITS: REED DWELLERS

Britain's population of the bearded tit is small, with some 400 pairs: but it is resilient, recovering from near extinction after the winter of 1946–47.

Above: A male bearded tit, with the 'beard' to which its name refers. This would more aptly be described as a black moustache, which begins between the eye and beak and extends to the sides of the throat. His head is lilac-blue, and he has a bright yellow bill.

Below: The female has a brown head and bill, and lacks the black moustache. The bill colour helps to tell the sexes apart, even at the nestling stage.

The bearded tit is instantly detected in its reed-bed habitat by the sound of its sharp, pinging call. Despite its common name, it is not a tit at all and many ornithologists prefer the old country name, the bearded reedling. Its nearest relatives are a group of birds known as parrotbills, which occur mainly in China.

This attractive bird breeds in the reed-beds of eastern and southern England and is rarely seen outside these sites. Like many small birds, the bearded tit is severely affected by hard winters such as in 1946-47. Indeed, after that winter the British population was reduced from some hundreds of pairs to only about half a dozen pairs in Suffolk and Norfolk. In earlier times it suffered an additional hardship, for it used to be an irresistible target for the Victorian fowler's gun–not to be eaten, but simply to be stuffed and mounted as ornament. Later it became popular as a cage bird, and this is still true today. However, since 1954 it has been protected under law and courts can impose heavy fines on anyone caught and convicted of molesting this bird.

Alternating diet One of the most remarkable features of the bearded tit concerns its diet. During the summer, like so many other small birds, it lives mainly on insects and other small invertebrates. Most other birds which feed in this manner migrate to warmer countries during the winter and hence continue to find similar food. The bearded tit stays in its breeding grounds or occupies another reed-bed, and adapts its way of life to feed on seeds –primarily those of the common reed. Such a change in diet involves a radical change in the digestive system: the bearded tit's stomach, in converting itself to the seed-eating way of life, swells to twice its summer size. This far-reaching adaptation takes place over a short period in the autumn, when days are shortening, and is reversed during the lengthening days of spring.

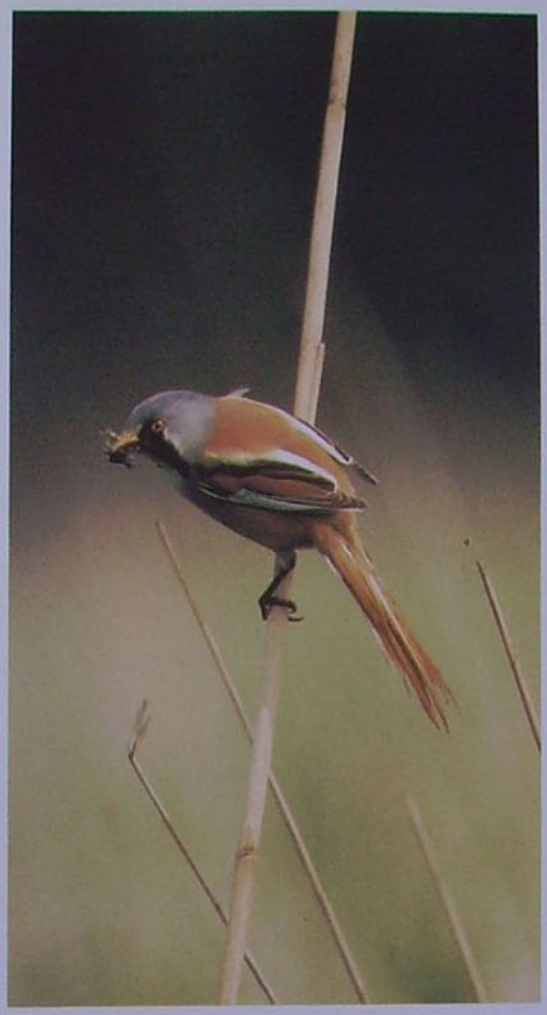
Populations of bearded tits can survive the cold weather of winter provided they can still find the seeds of the reed. If there is heavy snow they may find sufficient seeds in among the reeds where the snow layer is held off the ground by the vegetation. However, if the weather is very severe the reed-heads themselves can be encased in ice; then the birds may well starve. This is thought to be the reason why the winter of 1946-47 did so much more harm to bearded tits than the winter of 1962-63. In the former, glazed frosts were more prevalent and coated the reed-heads in ice, but this was not so widespread in 1962-63.

Recovery from disaster The bearded tit has a remarkable ability to recover from losses after bad winters. Breeding begins as early as April in good years, and pairs can rear up to three or even four broods in one season. Each clutch, laid in a nest deep in the reed-bed, may have six eggs and so the population will quickly multiply if conditions are good. It is thought

that the young birds of the year may help their parents (or neighbours) to raise later broods by bringing food.

Change in behaviour At times when their numbers are fairly small, bearded tits remain in the area of their particular reed-bed. But when their numbers increase beyond the capacity of the reed-bed, they cease to be sedentary and set off to explore the countryside in travelling flocks, looking for sites in which to start new colonies. This was observed in the British Isles in 1965 and subsequent years: despite their potential for quick population growth, their numbers had been so badly reduced in 1947 that it took some 18 years for them to outgrow their established colonies in the reed-beds of East Anglia. Observers in the autumn of these years in the mid-1960s noticed excited parties of bearded tits flying back and forth over the reed-beds, calling continually. It soon became clear that the birds were preparing to move out of their breeding grounds, at least for the winter. By ringing individual birds, it was shown that they travelled in their newly formed flocks for distances up to several hundred kilometres. Some subsequently returned to their native areas, while others established new colonies all over England, as well as in Wales and even, in recent years, in Ireland.

This behavioural change was also seen in the Netherlands, where a population of some 20,000 bearded tits is resident.



Left: A male pauses on a reed stem before returning to his nest with a beak full of food. Also seen here is the long tail, which is made up of finely graduated feathers–shortest on the outside, longest in the middle. The closest resemblance in British birds is to the long-tailed tit.

Bearded tit or **bearded reedling** (*Panurus biarmicus*). Resident in reed-beds. Length 17cm (6½in).

Birds of the reed-bed

Beds of the common reed (*Phragmites communis*) have always attracted birdwatchers, as they hold so many interesting birds–small ones such as the reed warblers in even the smallest reed-beds, and others such as the bittern or marsh harrier in larger beds. Each species has its own favoured nest site within this habitat. Those of the bittern and marsh harrier are made on the ground at the bases of reeds, often at the water's edge. The nests of the water rail and reed bunting are also on the ground but within the tangle of vegetation of the reed-bed. The bearded tit's nest is usually constructed low in the thicker parts of the reed-bed while the deep cup-shaped nest of the reed warbler is set quite high in the reed stems. Reed-beds, however, are a constantly changing habitat: if left undisturbed, they take only a few years to fill in and become dry land. To maintain the richness of bird life, the reed-beds need constant cycles of partial cutting and removal of reeds.

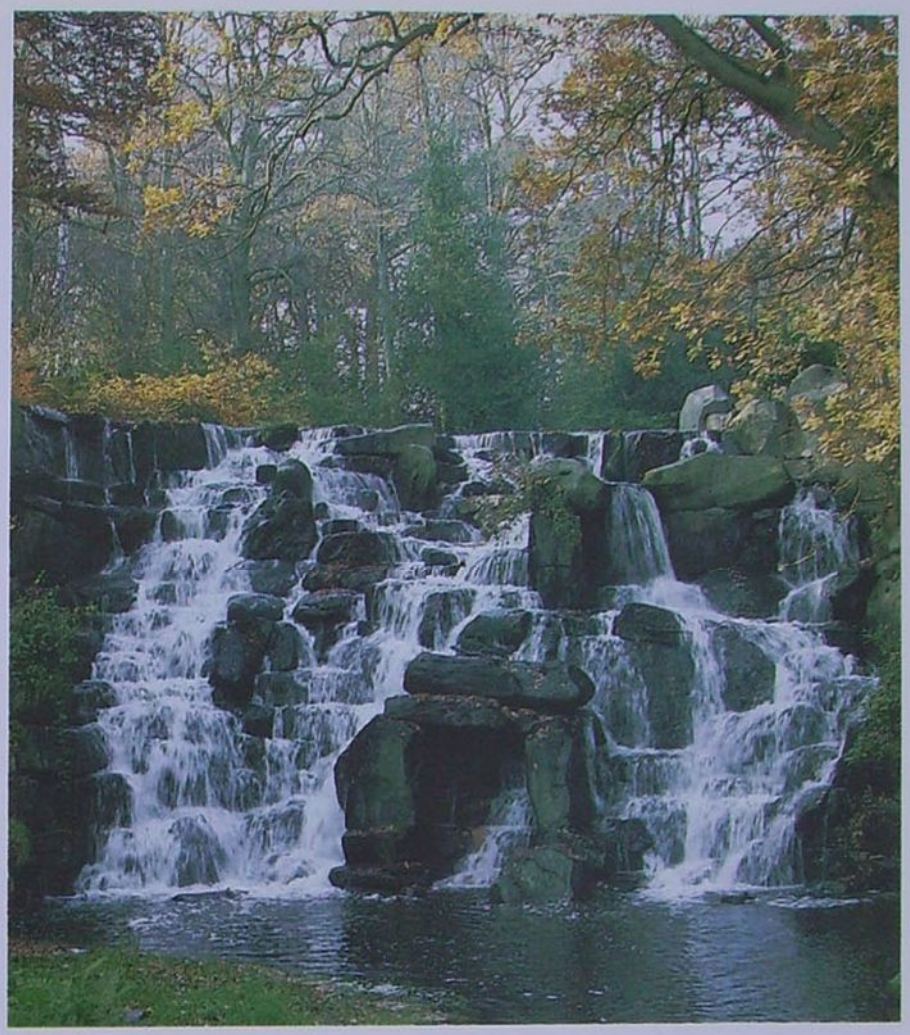
BRITAIN'S CHANGING LANDSCAPE

For the last 7000 years man has been developing the land to his needs so that today even the remotest corner of Britain is only semi-natural.

The history of British vegetation has been turbulent. For millennia, species of plants and animals had waxed and waned in response to climatic changes. Then man learned how to control and use nature, and the rate of change quickened dramatically. In broad terms that rate of change has continued to increase right up to the present. Today the wildest of landscapes can only be regarded as semi-natural, for even the remotest of upland or marine habitats have been altered by introductions, spread of diseases or air pollution.

The wildlife we see today is only that which has managed to adapt to man and survive despite his all-pervading influence. Those species which could not adapt contracted to the more remote parts of the country, but many could not live in the changed conditions.

Ancient forests By about 10,000 years ago a complete blanket of deciduous forest was covering Britain, following the improvement in the climate after the last Ice Age. We can only speculate on what this 'wildwood' was like, but we know from pollen remains that the main trees were oak, ash, elm, lime, hazel and birch. Was it a continuous, tall dark forest of stately trees, broken only by rivers and lakes? We suspect, from two main lines of argument, that it was not. First the modern flora of Britain has a high proportion of light-demanding species which do not survive under an unbroken canopy of trees, and they could not all have arrived after the first forest clearances because by that time Britain had been separated from the Continent by the rising sea level. Second, we know there were browsing animals which would have chosen to feed in the more open spaces with lusher ground vegetation, so they probably main-



Above: The waterfall in Windsor Great Park–formerly part of a Royal Forest which, when established by the Norman kings, occupied nearly half of what is now Berkshire.

Opposite page: Wild plants and animals are increasingly becoming confined to protected sites such as the Brecon Beacons National Park in South Wales.

Left: Rabbits are such familiar mammals of the British countryside that we often forget they are aliens. They have only been here since the 12th century when they were introduced for their meat and fur.

Right: The stone curlew is one bird whose numbers have decreased alarmingly as a result of the reclamation of heathland for agriculture. Its decline is also connected with the spread of myxomatosis among rabbits–stone curlews make their nests on patches of bare ground, often provided by rabbits digging into the heath.

tained permanently grassy clearings, often near water.

The dominant browsers would have been red deer, roe deer and wild cattle (aurochs). Other species that might have played their part in keeping the forest open included wild boar, bear, beaver and hare. The closed parts of the forest must have contained very large quantities of dead, dying and fallen trees and much of it was probably an impenetrable tangle.

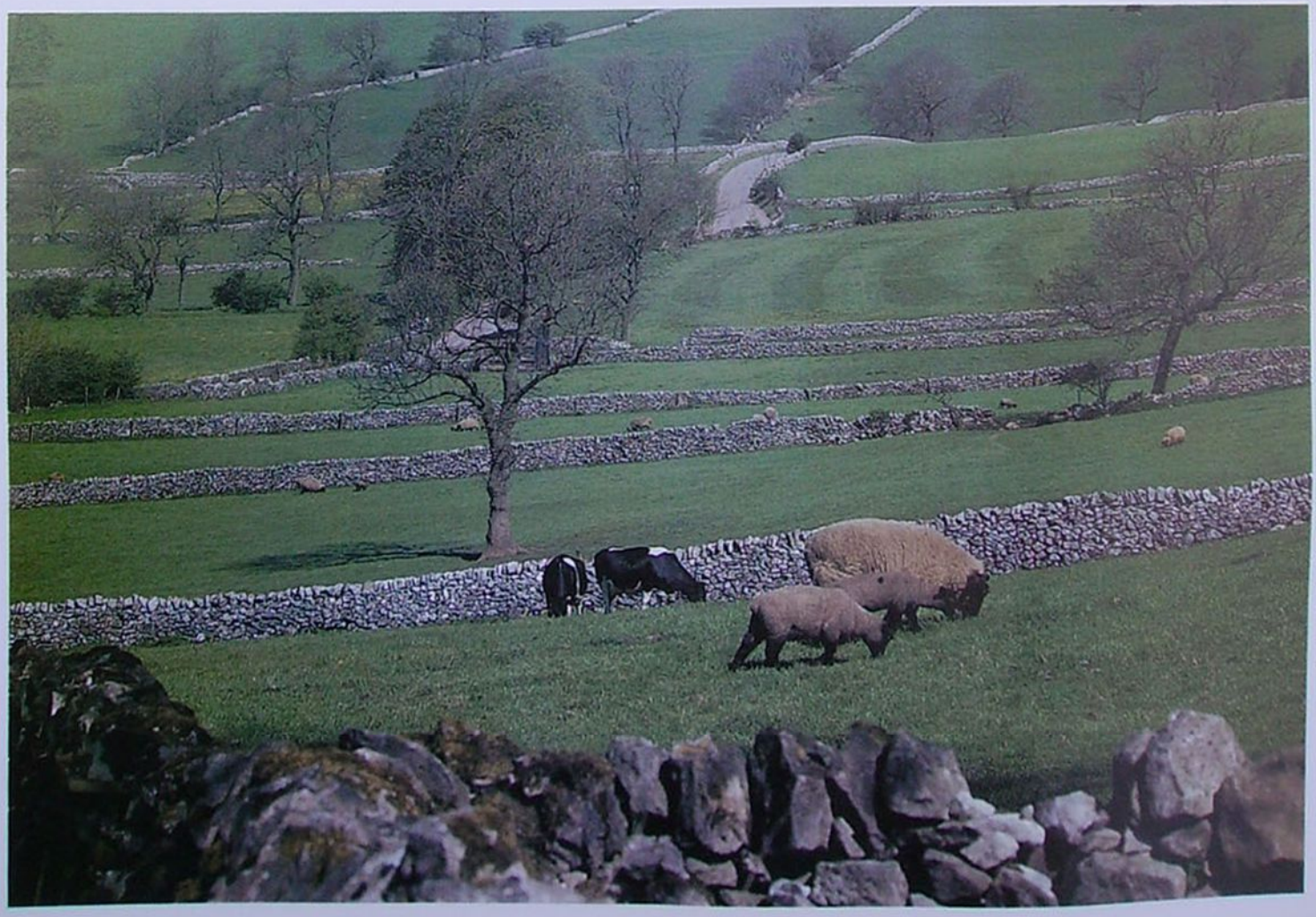
Clearing the woods The first man-made clearings in the wildwood are believed to have been made about 8000 years ago in Mesolithic times, but these were temporary affairs in which crops were grown for only a few years before the soil became too impoverished. Another piece of the forest was then laboriously laid waste with stone axes and fire, leaving the older clearing to revert to woodland.

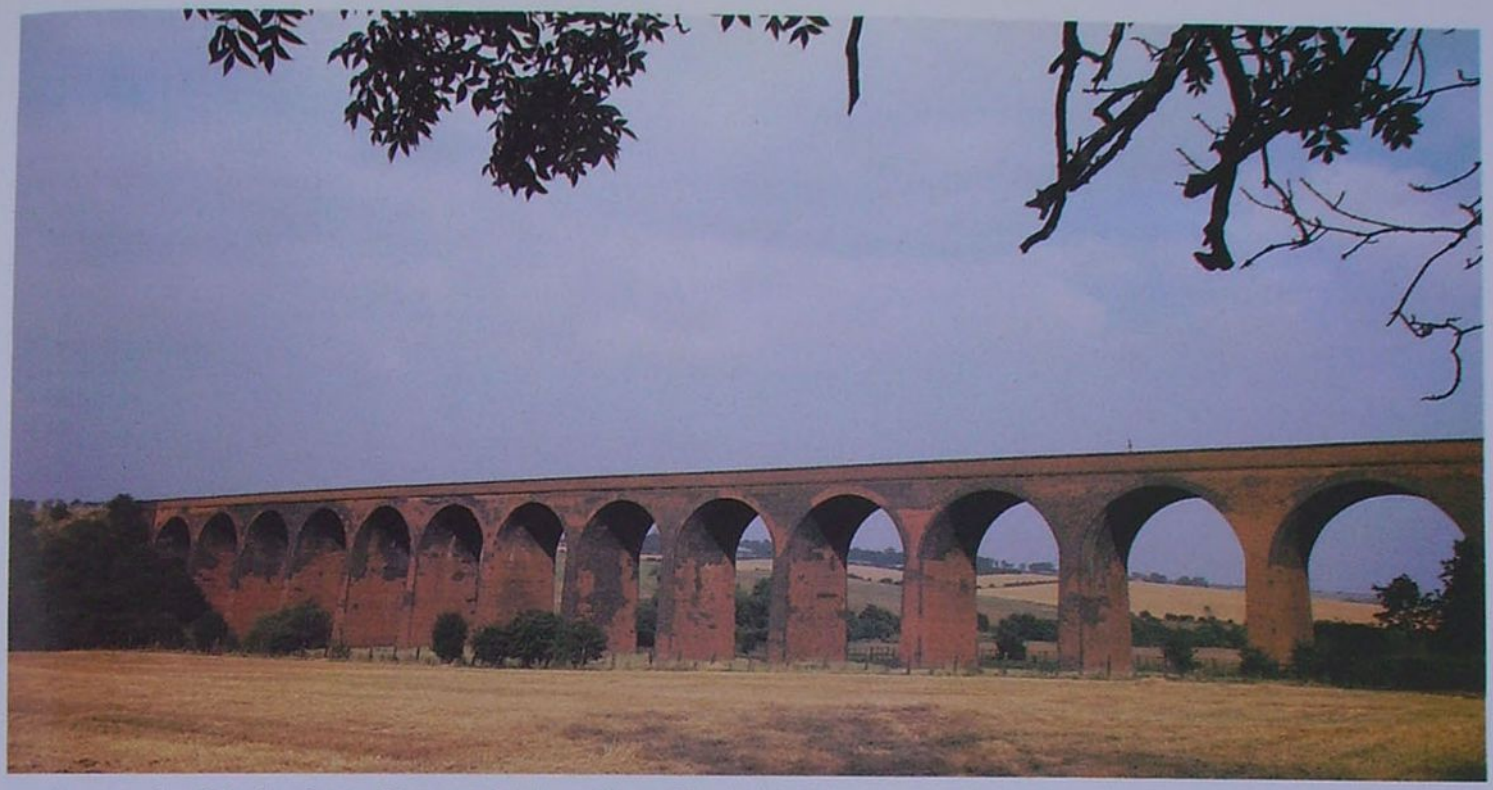
Neolithic Man, a few thousand years later, had a greatly improved understanding of farming, and by a system of rotation he was able to maintain the productivity of the land on a more long-term basis. A pattern of settlement gradually developed and the extent of permanently open land increased rapidly.

The arrival of the Romans heralded a period of settlement, establishment of communities, towns, roads and greater prosperity. The extension of farmed land at the continuing loss of woodland permitted the spread of plants and animals of open habitats, including

Left: The fact that the monkey orchid is still found in this country is due to the devoted work of conservationists who protect it in the few remaining sites where it grows–the Chilterns, the North Downs in Kent and Yorkshire. As a species which favours open chalk grassland it has suffered greatly in the wake of agricultural development on the downs. The plant's name is derived from the supposed resemblance of the flowers to a spider monkey.

Below: Dry stone walls in the Peak District, Derbyshire. Under the Enclosure Acts agricultural land was divided up into smaller fields for more efficient farming. On the rich lowland soils hedges were used for this, but on the hilly country, with a wetter climate and thinner soils that could not support hedges, dry stone walls were constructed.





weeds, grassland herbs, butterflies and birds of open country. Nature abhors a vacuum, so when another bite was taken out of the forest there would have been rapid colonization by non-woodland species. Because of the inefficient shallow ploughing, the amount of fallow land and rough grazing, the neglected strips and corners and the extent of woodland edges, this period would have supported a wildlife far richer in species than the original wildwoods.

Woodland management The Anglo-Saxon era saw a steady stabilisation of the pattern of woodland, so that by the arrival of the Normans it was more or less fixed. The numbers of domestic stock had increased enormously but woodland that was felled was allowed to regrow from the stumps by the simple expedient of excluding the animals with banks and fences. Another means of permitting regeneration was to cut the trees at head height so that the new shoots were out of reach of browsing deer, cattle and horses. These two systems, of coppice and wood pasture, became firmly enshrined in rural custom and were to stand the test of time for a thousand years.

The two systems produced highly contrasting habitats which were used in different ways by the native plants and animals. Wood pasture, with its open structure and abundance of old trees, was able to support a rich community of lichens, mosses, insects of dead wood and hole-nesting birds. Coppice, on the other hand, encouraged a rich ground flora and many nectar-feeding insects.

Enclosing the land Population growth continued, although the Black Death in the 14th century caused a major hiccup and much farmland reverted to a wild state. From the 15th to 18th centuries the trend was for ever-increasing order in the countryside. Legislation played its part in this: the repeal of Forest Laws protecting Royal Forests and the passing of countless Acts of Enclosure. Under these, land was gradually transferred from the Crown and the Lords to small private owners who laboured for generation after generation to increase the profitability of their farms. Heath and wasteland were reduced, boundaries were established and hedges planted.

The main check on the development of rural communities, all highly dispersed, was the difficulty of transport. Lanes and trackways had evolved primarily for the purpose of getting corn and livestock to market and each community had to be as self-sufficient as

Above: The Industrial Revolution in the 18th and 19th centuries transformed the landscape of the British Isles. As towns and cities expanded, acres of countryside were swallowed up under urban development. Even in areas that remained relatively rural, roads and railways ended the hitherto tranquil atmosphere.

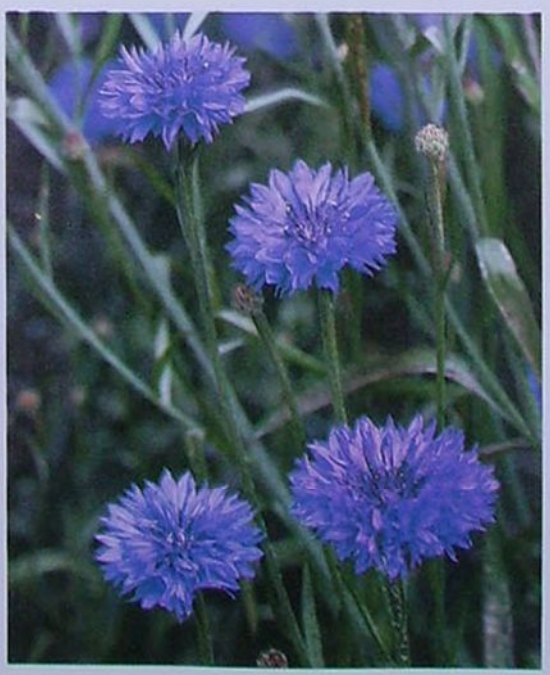
Below: Juniper trees used to be far more common on the chalk downs of southern England than they are today.

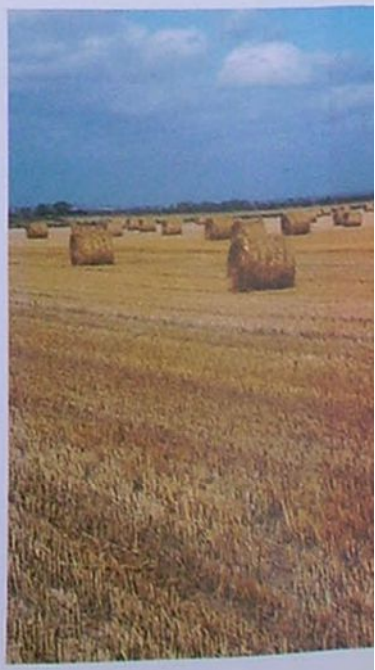
possible in order to reduce the need for travel. It was the coming of the railways which was to have the greatest effect in changing this rural pattern.

Industrial growth The Industrial Revolution had profound effects on the landscape and wildlife. Most obvious was the direct loss of semi-natural vegetation to industry, housing, mining, roads and railways. Of at least equal significance in the long term, however, is that it started a massive drift of population from the land to the new expanding towns. With fewer people striving to make a living from traditional crafts and practices, coppice rotations declined and people ceased to exercise their Common Rights. Previously nearly every parish had its Common on which cattle, horses, donkeys, sheep, goats and geese were grazed. As people turned their backs on this way of life many common meadows, downs and heaths were allowed to revert to scrub.

The First World War also left its mark on the countryside. Very few of the men who had gone to fight for their country returned to the traditional way of life after the war and so such practices as coppicing came to an end. Many woods had been stripped of all usable timber during the war years because of the interruption of imports, and huge areas of permanent grassland had been ploughed to increase home-grown food production.

After World War II there was an enormous effort to replant the devastated ancient woodlands. This movement was led by the state-funded Forestry Commission, but sadly they adopted the German style of forestry–clear felling and replanting dense new crops in large blocks. Most of the trees planted were exotic coniferous species so our native woodland flora was unable to adapt to such an abrupt change. Some insect groups, however, notably butterflies, were able to





Above: Gloomy conifer plantations, such as Gwydyr Forest in Snowdonia, are relative newcomers to the countryside.

Below left: As a result of seed-cleaning techniques attractive cornfield weeds, like cornflowers, are now much rarer than they were.

exploit the open conditions of the early years of the plantations. But since most of the planting was completed by the 1960s, we are now entering the darkest phase of the crop cycle and our woodland butterflies are declining pitifully as their last refuges are shaded out.

Today's agricultural revolution The nature conservation movement started in Britain in the late 1940s. The emphasis in those early years, however, was on safeguarding the foremost ecological sites and on reducing the impact of urban and industrial development. It had not been predicted that the major threat to wildlife was to come from agricultural change.

In the last two decades there has been a second Agricultural Revolution, with many developments which have impinged on wildlife. Hedges, scrub and woodland have been ripped out to bring more land under corn cultivation; techniques of land drainage have advanced and rivers have been deepened and straightened to prevent flooding; fertilisers and pesticides have been further developed and are used on a scale that would have astonished the pre-war farmer. All this, with ever-increasing mechanisation, has boosted agricultural production by a few orders of magnitude, but the toll on wildlife has been very heavy indeed.

Most of the changes in the landscape, particularly since the last war, have reduced and simplified semi-natural communities. There have been some gains, however, and some adaptable species have actually increased. The creation of reservoirs and flooded gravel pits has provided new habitats for many species, such as tufted duck, pochard, great crested grebe and little ringed plover. Many copses and shelter-belts have been planted in the lowlands, providing a habitat for a great many common species, and in the uplands huge afforestation programmes are underway.

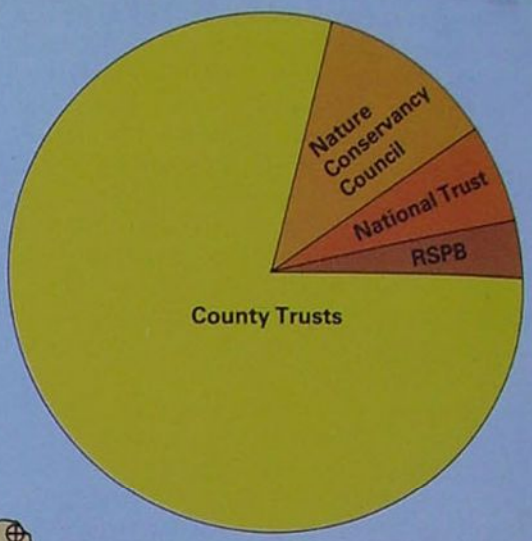
A continuing threat Today there is an increasing sympathy for nature conservation but government and EEC policies still threaten our wildlife. There will have to be substantial changes in grants and guaranteed prices if we are not to suffer further losses, and it remains to be seen whether conservation can be achieved voluntarily, with financial compensation where necessary, or whether much greater compulsion will be required.

Above: Thursley National Nature Reserve in Surrey is one of many conservation sites established since the 1940s.

Below: Barely a hedgerow in sight–the advent of vast farm machinery has encouraged arable farmers to grub out their hedges.

Conservation sites

The aim of the conservation movement is to protect the countryside from urban, and more recently agricultural, development, and so most smaller conservation sites occur in densely populated or intensively farmed areas. In Ireland where the pressures on the land are not so great fewer protected sites exist–indeed the Irish government has only recently started designating them.



Above: A pie chart showing the proportion of sites owned by the main conservation groups. These are the Nature Conservancy Council which aims to protect specific habitats and species, the National Trust which sets out to preserve landscapes, the RSPB–a group formed to guard areas of ornithological interest, and scores of county trusts dotted across the country.

THREE ACRES AND A COW: SMALLHOLDINGS

Despite the economic pressure on farmers to work larger and larger areas of land, there are still many up and down the country who manage to earn a modest living from the few acres of a smallholding. For a privileged few the way of life has been adapted to provide a form of self-sufficiency.

Above: A family needs a house and at least five acres to achieve even a modest degree of self-sufficiency. Three acres for each cow is the traditional figure, but with the current high cost of land, owning a smallholding which produces enough food and fuel is beyond the reach of most people.

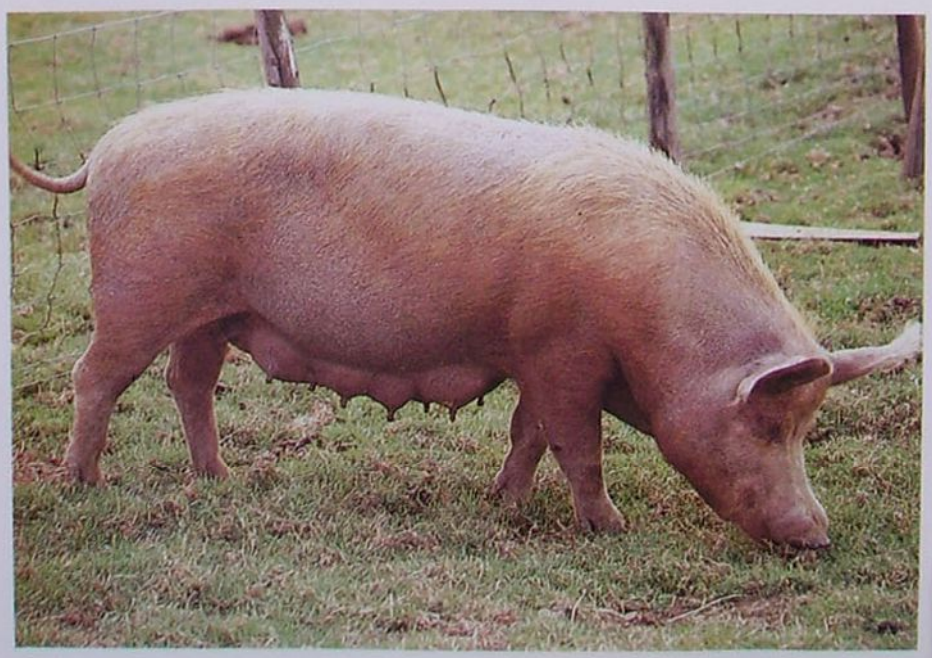
Below: Rabbits are very efficient meat producers for the smallholder with limited space.

There are over 24,000 farms in the British Isles. Half of these are substantial commercial businesses, and the source of 90% of the agricultural produce which finds its way on to the market. The other half–although this number diminishes every year–are small-scale one-man enterprises which, between them, produce about one tenth of the national output.

Part-time farms Many of these smallholdings are extremely small, but they provide the only earned income of farmers unable to obtain larger holdings. Despite this they are nearly all officially defined as part-time, on the principle that no farm under a certain size can provide full-time work for anyone. This renders them ineligible for many of the Ministry of Agriculture grants available for

Above: Ducks and (below) a Tamworth pig on a smallholding. Unlike sheep or cattle, these do not (indeed cannot) eat vast quantities of grass, so the relative lack of this material on a small acreage does not matter. Such food as the animals find on the land is a supplement to the main diet which is bought in from outside–either specially made compound foods or waste food from bakeries, dairies and catering establishments. The latter is the basis for pig swill, which must be boiled for an hour, by law, to kill disease organisms that may lurk in imported meat products. Boiling is a nuisance, but pigs like the result.

Left: Two kids being bottle-fed. Goats can be housed in confined space and fed on hay, roots and green fodder such as cabbage and kale.



the improvement of larger 'viable' farms. The stigma of 'non-viability' makes financiers reluctant to invest in them, and the combined effect is that most smallholders are under-capitalised, relying on second-hand equipment and a lot of hard manual work.

The consequence of this is that, whereas large-scale farmers achieve a high productivity per acre at high cost, smallholders normally achieve a lower productivity per acre at very much lower cost; in other words, they are often more efficient. Normally, the larger the farm, the more economic it is, because expensive machines and installations may be used to their full capacity instead of lying idle. Below a certain point, however, expensive machines do not make sense. A four-wheel-drive tractor and five-furrow plough costing at least £20,000 is of no use to the smallholder who needs to cultivate half an acre of land, even if he could afford it. He is actually better off with a small, three-year-old tractor bought for a song at a farm sale, or even a horse. Better still, he could dig the land over with a spade. It would be very hard work, but it is possible, practical and free. Some would even enjoy it.

Most smallholders avoid the problem of cultivation altogether by concentrating on livestock. The animals benefit from the close attention they receive on a small farm, and they do not involve much in the way of mechanisation or hard manual work.

Animals The most popular animals for the smallholding are naturally those which can be kept on a small area, such as pigs and hens. They can be fed on specially made compound and whole grain foods which are used by the big chicken and pig farmers but these have become very expensive owing to the high price of cereal grain maintained under the Common Agricultural Policy.

Few smallholders can afford to maintain their stock by this means alone; indeed, few of the big farmers can either (which is why so many of them are going out of business). Fortunately, the smallholder, with fewer animals to feed, is able to reduce costs by feeding waste food bought in from caterers or shops, or waste from the kitchen and vegetable garden. Pigs thrive on potatoes, for example, and on a smallholding it may be worthwhile growing a patch of potatoes, selling the marketable crop and feeding the rest to the pigs.

Because the price of commercial pig and chicken feed is so high, the big producers have devised systems which improve 'feed conversion' into meat and eggs. The animals are housed under conditions of optimum temperature and light level and discouraged from moving about. Most of the pigs and hens bred today have been specially developed to perform well in these factory farms and are quite unsuitable for smallholdings, where there is much to be gained from letting the animals out to forage for themselves. Con-

sequently most smallholders continue to use traditional outdoor breeds such as British Saddleback pigs and Rhode Island Red chickens, and keep them in rudimentary housing knocked together from re-used timber, old doors, corrugated iron and similar materials. The average smallholder is a great believer in make-do-and-mend, by necessity and by tradition.

Sheep are normally not economic on a limited acreage as they need too much grazing land, but goats are popular. Like cattle, they can be housed and fed on produce from the smallholding itself or which is bought in from nearby farms. Both are kept for milk, and in the case of cattle it is usual to select extreme dairy-type cows such as the Jersey, which gives rich milk ideal for converting into dairy products or for selling at a premium price as fresh 'green top' untreated milk.

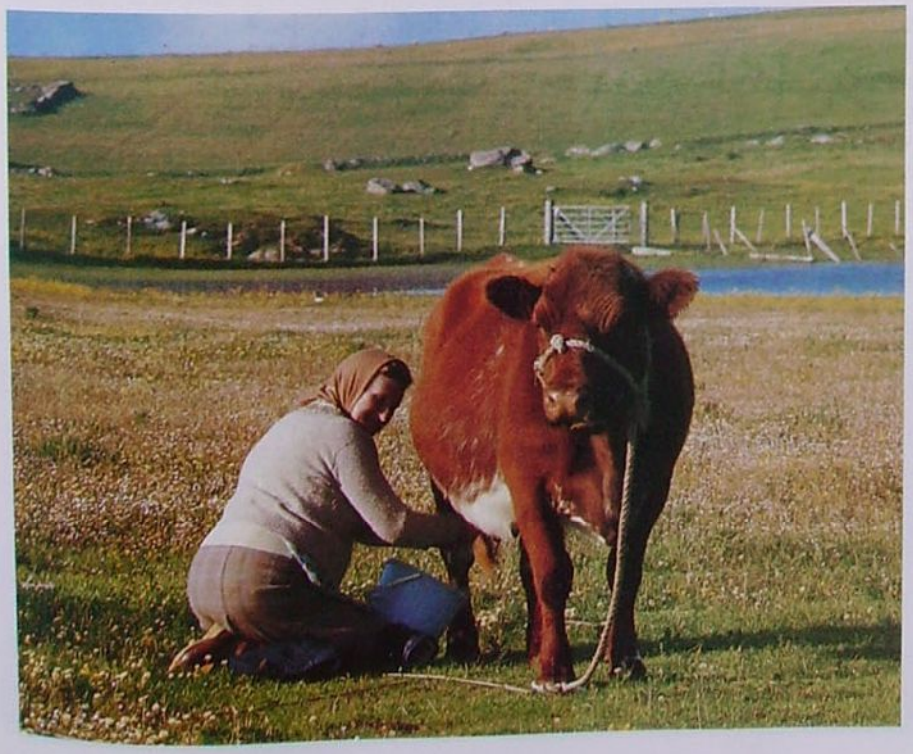
Special products This emphasis on specialist products is fundamental to the smallholding economy. Bulk producers of popular products can afford to charge very low prices, and the only way the small producer can compete in the market place is by selling goods which the large companies find uneconomic to produce.

The anti-factory farming movement and the revival of interest in fresh, unprocessed foods have benefitted the smallholder enormously. There is now a steady living to be made from free-range eggs and chickens, goats' milk and cheeses, farm-fresh butter and cream and organically grown vegetables. With the growth of the home freezer market, it is even possible to sell free-range pigs.

An interesting variation on this idea is the development of the rare breed trade. Owing to the efforts of the Rare Breeds Survival Trust there is now a small but flourishing market for breeds of livestock which are no longer used by big commercial farmers because they are unsuited to current systems of farming.

Above: Free-range chickens running in the stubble where they pick up grain. The growing anti-factory farming movement has meant that smallholders can make a useful income from the sale of free-range eggs and chickens, whether directly from the farm, through local shops or in the market.

Below: A smallholding in the Outer Hebrides owns this one cow, Rosy, and she provides milk for the family. The surplus goes to neighbours.

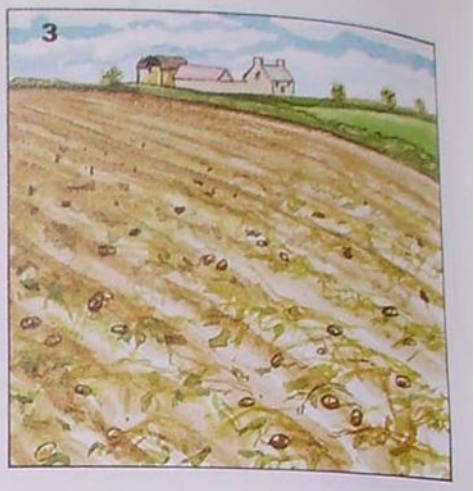


These qualities are also useful to the smallholder. Rare breeds of pigs such as the Tamworth and the Large Black, for example, are hardy outdoor creatures which do well on a smallholding. The diminutive Dexter cow is a perfect small-scale dairy animal which also produces useful small joints of beef. Coloured breeds of sheep such as the spotted Jacob, Black Welsh Mountain and coloured Shetlands can be worth keeping in small numbers for their wool.

The main value of such animals, however, is as breeding stock. The survival of many of the rarest breeds depends on the establishment of several different bloodlines (unrelated or only distantly related families) and the more independent breeders there are, the better. By producing animals for auction at the rare breed sales, a smallholder can earn quite a nice income, as well as make a useful contribution to the future of livestock breeding.

The function of the traditional smallholding is to produce goods for sale. Specialisation is the rule: a smallholder will concentrate on producing eggs, or vegetables, or dairy produce, take it to the local town and sell it either in the street market or to a retailer. The motivation is strictly commercial, and the producer will have no hesitation in buying most of the food for his animals from outside suppliers, if the market justifies the cost. If some of the produce can be kept back for home use, so much the better, but its main function is to earn money.

Recently, however, a different kind of smallholder has appeared–to the envy of many city dwellers. His aim is to produce a variety of crops and avoid buying anything in from outside: the ideal is self-sufficiency.



A basis for self-sufficiency

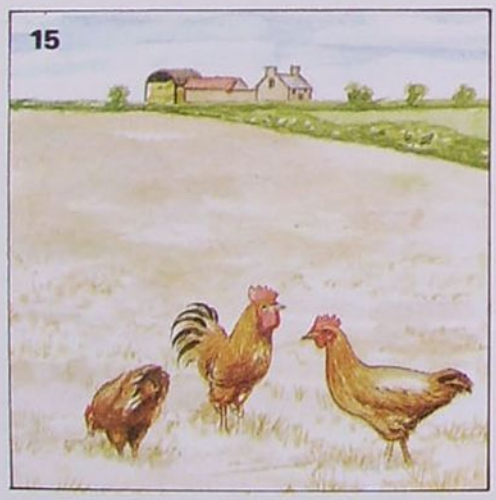
Over the last 20 years a new type of smallholder has appeared who sees the activity as a way of achieving an ideal: self-sufficiency. True self-sufficiency is impossible to achieve in Britain today, unless one is prepared to accept a standard of living intolerable to the average European. Consequently most would-be self-supporters either have another job or produce goods for sale in the normal way. Nevertheless, a large proportion of the holding will be given over to the production of food for home use, or for barter with neighbours, and for this purpose too much specialisation is a mistake. The self-supporter aims at variety–a little of everything.

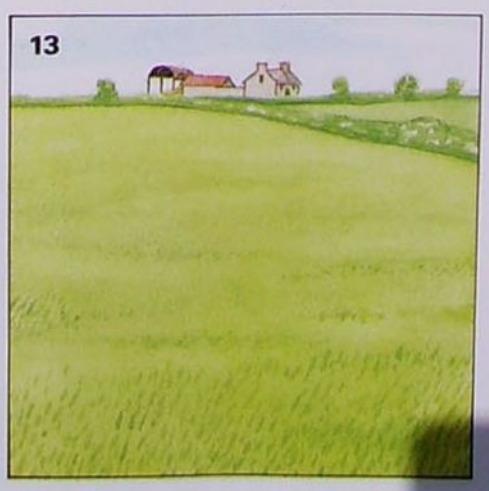
A couple of hardy pigs can be run on a potato field (**1, 2**) after the crop has been lifted (**3, 4**). By confining them to a small area at a time, they are encouraged to rootle about thoroughly, finish up the unlifted crop, eat out the weeds, including tenacious perennials such as couch grass, relieve the soil of any insect pests, churn it up (saves digging) and manure it for the next crop.

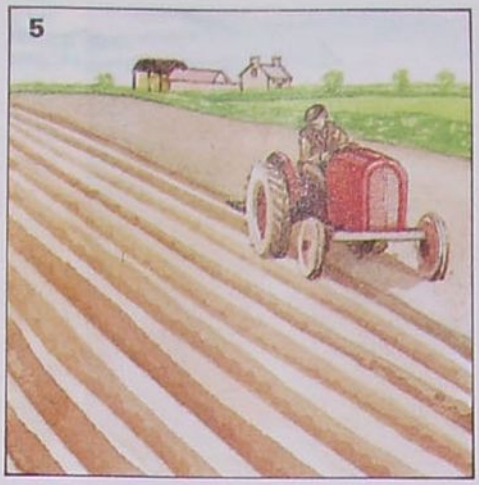
By the end of the winter the land will be in excellent condition for a spring-sown cereal crop such as oats (**5**). While the oats are still green in the early summer they are mown with a scythe (**6**), or a tractor-mounted cutter bar (a combine harvester is hardly practical for a smallholding) and kept for feeding to the dairy cows the following winter. Fed whole, in the sheaf, the oats will provide all they need in the way of protein, carbohydrate and fibre.

Meanwhile, the harvesting of the oats has revealed a fine crop of undersown grass and clover which will feed the cattle for the rest of the summer and autumn (**7**). Rested over the winter (**8**) while the cows eat the oats, this temporary grass will provide excellent grazing the following spring (**9, 10**), boosting the milk yield and encouraging the smallholder to make butter and cheese. The by-products of this small-time dairy industry go to the pigs, which thrive on it.

By autumn the turf is well manured and ready for ploughing into the land before the crop of wheat is planted (**11-13**). This is cut when it ripens early the following summer (**14**), dried in the sheaf and stacked in a rick or barn for threshing later on. The wheat straw can be used for thatching, or even to make dollies to sell, and the







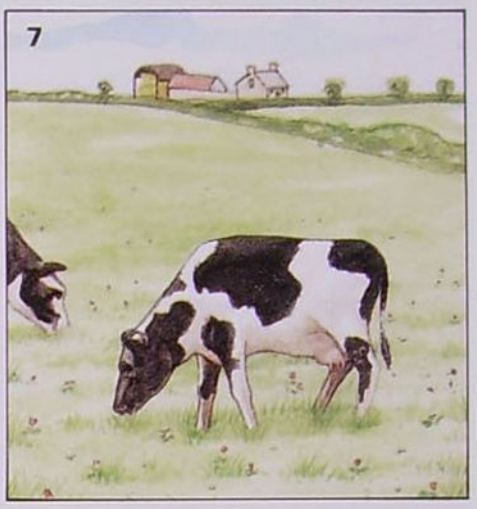
surplus makes perfect litter for cattle. While the wheat is drying in the field the hens forage among the stubble for spilt grain, weed seeds and insect pests (**15**), cleaning it up nicely before ploughing, and saving money being spent on chicken food.

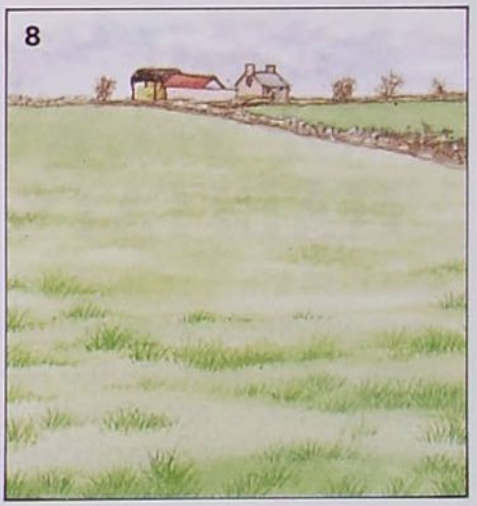
The land is then ploughed (**16**), left over the winter and ploughed again in spring to kill the weeds and incorporate the manure which has accumulated in the cowshed. Assuming there is enough manure (there never is), the soil will be ready for another crop of potatoes (**1**), or a similar root crop–swedes, turnips, carrots, fodder beet, for example. Planted in rows to allow weeds to be hoed up, they are ready for lifting in October or November, after which the field is turned over to the pigs once again.

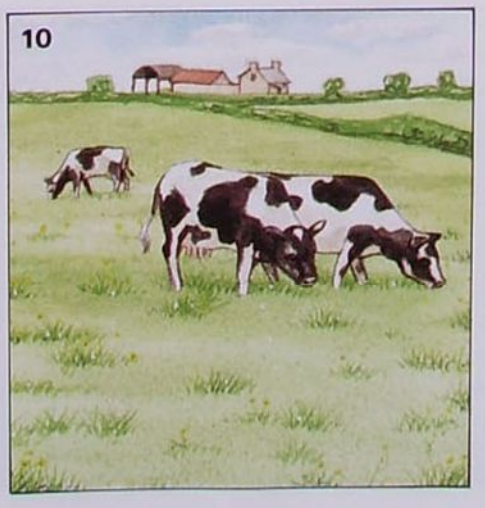
This four-year sequence is a variation on the Norfolk four-course rotation which was almost universally employed on the mixed farms in Britain during the 19th century. Its advantages are obvious: it is more or less self-supporting and it provides a variety of produce–wheat, oats, milk, cheese, butter, pork and bacon, potatoes, chickens, eggs and even corn dollies. Practised on four small fields at once, each at a different stage, it is a good basis for self-sufficiency. Furthermore, it is a picturesque, wholly organic, free-range system, and these things are important to the type of smallholder who aims at the good life.

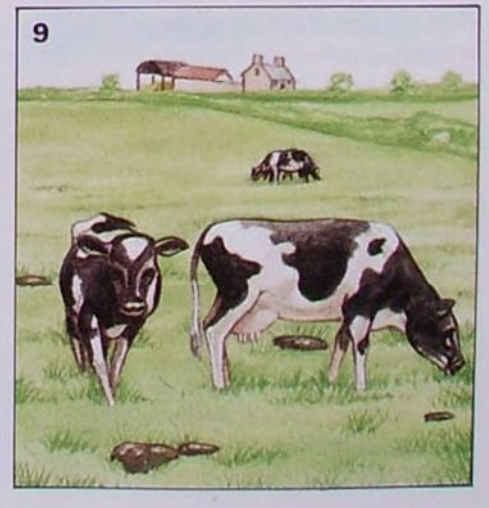
Whether or not this system works depends on the skill and energy of those who attempt it. Traditional husbandry involves a lot of hard work, and an understanding of plants and animals that many enthusiasts find difficult to acquire. Even so, it is a forgiving system; in-built checks and balances make real disaster unlikely and the beginner can learn on the job.

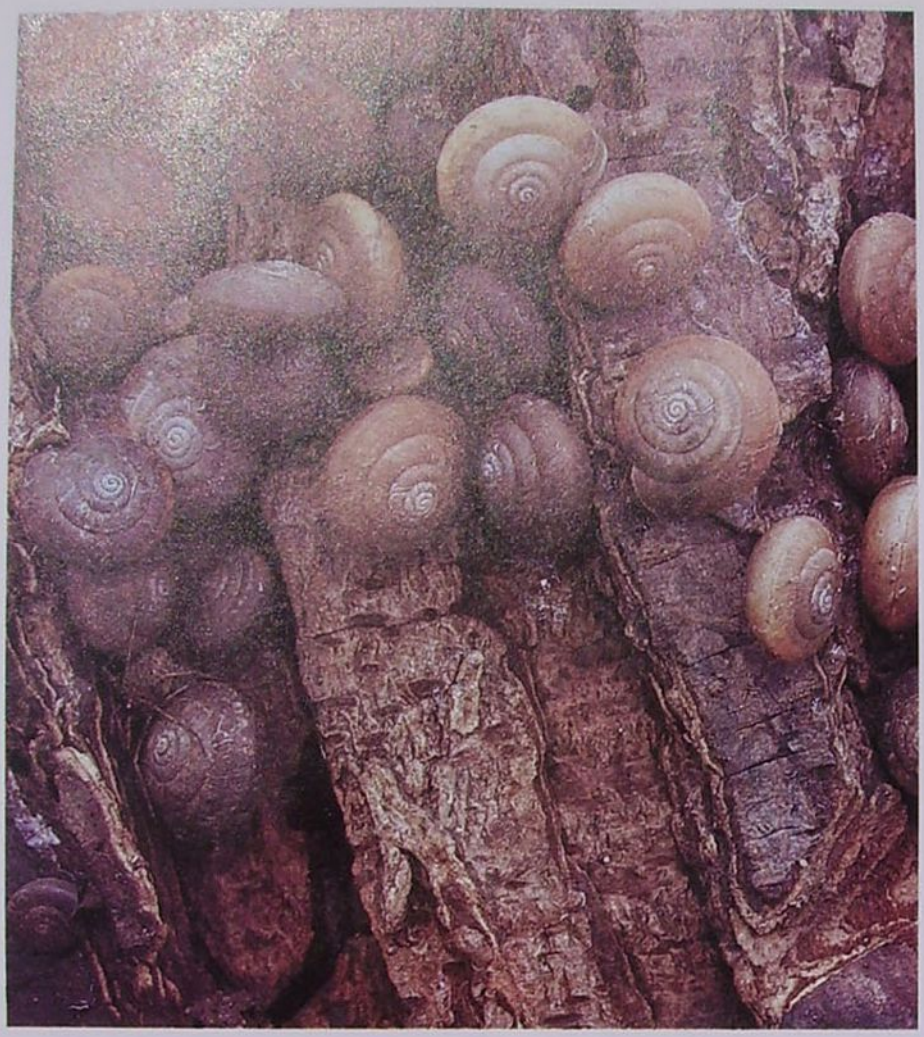
The main problem with self-sufficiency is getting enough land in the first place. Owing to the current agricultural boom, the value of even rough farmland has risen rapidly over the last few years. In December 1981 the average price of farmland in England was £1652 an acre. Even very poor land, which fetched about £15 an acre in the 1950s, has been going for £1000 an acre or more. A family needs a house and at least five acres to achieve even a modest degree of self-sufficiency. Three acres for each cow is the traditional figure. The outlay involved is considerable, and beyond the means of many potential self-supporters. It is ironic that a way of life which, ideally, makes cash transactions almost unnecessary, can today be adopted only by those with a great deal of money to spare.











SNAILS OF WET HABITATS

About 15 kinds of snail live in the wetlands of the British Isles. Some are adapted land dwellers, some are aquatic and several are truly amphibious.

Above: Part of a gathering of *Trichia* snails (either *T. plebeia* or *T. hispida*). They have climbed a waterside poplar to escape not flooding but drought–this spot being the last damp place they can reach as their habitat dries out.

Below: A young *Trichia hispida* browsing on a damp patch of leafy liverworts. It is not known for certain whether the hairs on its shell serve any useful purpose.

Marshes and riverside fields provide unstable habitats, fluctuating between land and water. For much of the winter they may be completely submerged, whereas in a hot summer they can dry out with a layer of hard, caked mud. The snails that occupy this intermediate habitat must be able to cope with the variation in conditions, and some are amphibious. The many kinds of snail that are characteristic of wetlands comprise representatives of two distinct evolutionary pathways: those that have adapted to wetland life from a purely aquatic ancestry; and those that originate from snails with fully terrestrial life-styles.

Aquatic ancestry One group of snails, called the Basommatophora because their eyes are set at the base of their tentacles, are primarily aquatic, but at one stage in their evolution they lost their gills and developed the capacity to breathe air from the atmosphere. This allowed them to survive regular exposure on the seashore, or to breathe at the surface when oxygen levels in ponds and rivers became too low. They can also breathe through their skin, while some groups, having reverted to a fully aquatic existence, have developed a new form of gills.

Snails of one basommatophoran family, the Lymnaeidae, can be recognised by their flat, triangular tentacles; most live in fresh water but can often survive buried in the mud of a pond if it should dry up. Some inhabit marshy places, and *Lymnaea palustris* is truly amphibious, crawling freely through damp grass or living a totally aquatic existence in ponds or streams.

Another member of the Basommatophora is the tiny snail *Carychium minimum*, which is a member of the family Ellobiidae. This family is mostly composed of larger snails inhabiting tropical mangrove swamps, but *Carychium minimum* lives in a wide range of damp habitats, being particularly abundant in the flood plain of large rivers.

Eyes on tentacle tips The majority of land snails belong to a group called the Stylommatophora, whose eyes are set at the tips of their tentacles. When the tentacles are withdrawn, a muscle attached to the back of the eyes contracts to turn the tentacles like the inverted finger of a glove. Unlike the Basommatophora, the Stylommatophora are never fully aquatic, but they can inhabit the wet zones intermediate between land and fresh water.

One stylommatophoran family, the Succiniidae, or amber snails, nearly all inhabit the zone extending from the waterside plants to damp meadows. Of our several British species, *Oxyloma pfeifferi* favours the immediate neighbourhood of river banks, whereas *Succinea putris* can be found all over wet meadows.

Some authorities claim that the Succiniidae are a primitive group that demonstrates the transitional stage which land snails passed

through when they evolved from freshwater snails. More recently, the view has been expressed that they are evolved from true land snails but have secondarily acquired features that appear primitive because of their life-style in a wet environment.

Rarer snails Some snails that have undoubtedly evolved from fully terrestrial forms now inhabit only very wet conditions. The family Clausiliidae includes members that inhabit a range of conditions, which in south-eastern Europe include many species that spend the summer cemented to the hot surfaces of rocks and walls. Most of our British species live in woodland, but one, *Balea biplicata*, lives in rivers in a few widely scattered colonies in the south of England. It was once abundant along the London tidal zone of the River Thames, and continued to survive in colonies at Chelsea, Fulham and Putney until recent times. It is still abundant on Isleworth and Brentford Aits, but these larger Thames islands, which are refuges for a number of rare waterside plants and animals, have been threatened with large-scale development.

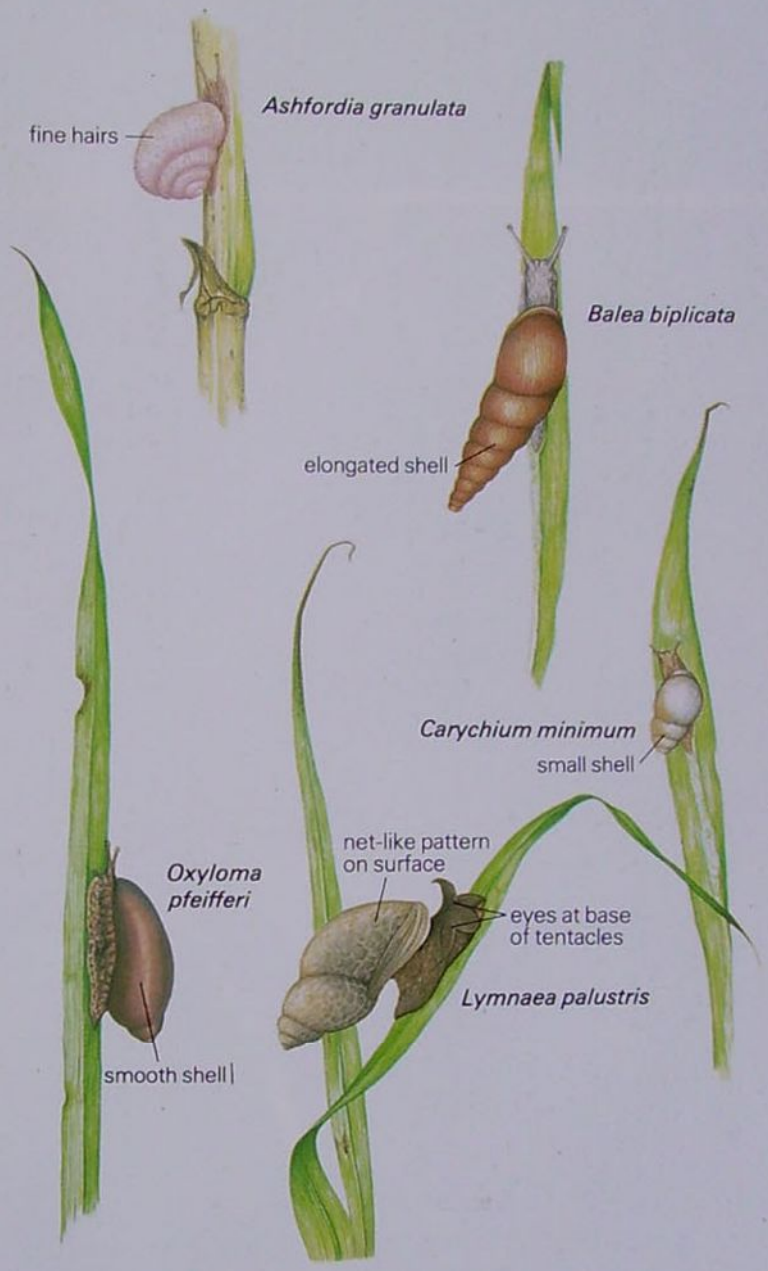
On these islands *Balea biplicata* lives under the loose flood debris that lies scattered between the large trees that cover this vanishing type of habitat. A large piece of debris can harbour some tens of this species under it, including numerous young which, because the adults retain the eggs in their bodies until they hatch, are produced fully developed.

Another rare snail that occurs here is a member of the family Helicidae, *Perforatella rubiginosa*. This snail has only been recognised as occurring in Britain in the past few years, although it has been known from parts of Continental Europe since the middle of the last century. *Perforatella rubiginosa* has been overlooked in Britain until now, probably because of its close but superficial resemblance to a number of other members of the Helicidae that live in damp conditions, such as *Trichia plebeia* and *Ashfordia granulata*. All these snails have globular shells that are covered in numerous hair-like growths, and it is easy to see how they have been confused, although internally they are quite distinct.

Perforatella rubiginosa lives in the more muddy areas of Isleworth Ait and Brentwood Ait, and also the intervening stretch of Syon Park that borders the Thames. It has also been found in a similar habitat at Aylesford in Kent but, more interestingly, a smaller form has been found in water meadows bordering the Thames in Oxfordshire and Berkshire.

Although it lives in wet conditions, *Perforatella rubiginosa* will soon drown if immersed in water during the summer. It does not face this risk in winter, for when conditions become cold it survives by burrowing into the substrate, forming a barrier of dried mucus over its aperture, and then hibernating.

Five wetland snails



Left: Two amber snails, *Succinea putris*, on a plant stem. They are not aquatic, and might better be called amphibious: these snails can be found either at the water's edge or throughout wet meadows. They climb up tall plant stems like this to escape from flooding, and this is characteristic of the whole of their family, the Succiniidae. It is just possible that this behaviour is an indication that their ancestors may have lived on dry land.

Above: Many woodland insects have suffered greatly from the isolation of habitat. The fragmentation of woods in eastern England has led to the extinction of the pearl-bordered fritillary from many of its previous strongholds. This species, along with many others, would have a much better chance of survival in a series of linked woods such as those in the picture below, taken in Bedfordshire.

BIOLOGICAL ISLANDS

In recent years changes in land use and farming practice have led to the break-up of our countryside into small units, with drastic effects on insects and other creatures.

Before man began to alter his surroundings through agriculture, the woods, grasslands and marshes were all part of a continuous mosaic of habitats. Each graded gently into the next, and animals or plants were able to travel from their patch of habitat to another similar patch. The ever increasing pressure on the countryside through drainage and general 'improvement' of the land has reduced this natural mosaic to small isolated patches in a sea of arable land.

Our wildlife has reacted in different ways to this change. Some animals and plants are well adapted to cope with the problem of dispersal over long distances and colonization; but others are less mobile and thus unable to disperse between fragmented habitats. This last group includes many small creatures, such as insects, which for physical or behavioural reasons cannot move to new habitats if their present one is surrounded by fields. Such species are isolated just as surely as if they were on an offshore island–they are living on biological islands.

Barriers to movement The isolation of an island in the sea or a lake is obvious–only those animals able to swim or fly stand a chance of leaving or colonizing such an island. The barriers in land-bound biological islands, or habitat islands as they are often called, are much more subtle.

The barrier may be physical; a system of drainage ditches around a field can often isolate ground dwelling insects and other small animals which cannot fly; or the distance between patches of habitat may simply be too great for an adult insect to crawl, hop or flutter.

Most barriers between biological islands are often difficult to appreciate without a knowledge of insect behaviour. Despite their agility in flight most small insects avoid long distance flights. This behaviour keeps the insect within its chosen habitat and prevents it from straying away from the rest of the population and its food. Even the most energetic of our butterflies, with the obvious exception of naturally migratory species, do not travel far from their emergence site. Even moths in a woodland avoid open spaces and

Left: This aerial view of the New Forest shows a type of biological island not always apparent on the ground: a stand of native broad-leaved trees bordered by introduced conifers. Forest insects are likely to find such blocks of conifers as much a barrier to them as open fields.

Above: The reduction of fenland to small patches, such as this last remnant of Borough Fen, almost certainly caused the extinction of the large copper butterfly (above right) in the late 19th century.

Below: Bare mountainsides of the Scottish Highlands are the home for isolated colonies of the mountain ringlet butterfly (below right). This species retreated to these sites after the last Ice Age.

shun the wide expanse of fields.

Natural islands In the long term, the process of small patches of land, with their communities of plants and animals, becoming isolated is an essential part of evolution. Many of our British arctic-alpine plants and animals were stranded here after the last Ice Age, some 10,000 years ago. When the ice retreated these species had either to adapt to the changing conditions or to retreat into mountain-top refuges. This last option was taken by the mountain ringlet butterfly which is now only found in the English Lake District above 550m (1800ft) and the Scottish Highlands over 450m (1500ft). It cannot colonize adjacent grassland because its larvae cannot survive in the warmer climate of lowland valleys. In the relatively short space of time since the last Ice Age the English and Scottish populations of mountain ringlets have altered in size and pattern until they are now considered to be separate sub-species.

Rapid isolation In the early part of the present century most of the British Isles had a rich and varied wildlife. Small fields were linked by wide hedges, and field margins were left unploughed. These provided a route for insects to disperse from field to field or wood to wood.

Today, the creation of large fields and the grubbing of hedgerows have led to the removal of these natural highways and the reduction of woodland to islands in a sea of cereal crops. The greatest danger facing insects of small biological islands is that of extinction. All populations naturally fluctuate with good and bad years, and cycles of extinction and recolonization are part of the natural pattern of insect life. Once a species becomes extinct on a small habitat island the chances that it will reappear depend upon the mobility of the species and the distance to the next population.

Pockets of fen Changes in the landscape of the Somerset Levels and the East Anglian Fens began a long time ago when man first began to dig peat for fuel. This activity maintained the fenland habitat and stopped marshes developing into dry land and even-

tually woodland.

Extensive drainage of the fenlands in the 1800s rapidly reduced the area of fen until today we are left with small pockets of wetland among huge expanses of farmland. Most of these remnants are nature reserves which need careful management to maintain them as a fen. These are classical biological islands which have produced sub-species of insect unique to Britain. A well-documented example is that of the swallowtail butterfly, once widespread over the Fens and now restricted to one main site in Norfolk. In less than 100 years there has been a reduction in the average wingspan of the British race of swallowtail as their isolated colonies had to adapt to become less mobile, thereby avoiding wandering away from the few suitable habitats remaining.

Marginal land Before World War II there were lots of small pockets of marginal land around the corners of fields and on hillsides, ideal for rich grassland communities of insects and plants. The need for increased food production during the war meant that much of this land was ploughed and planted. Today, such marginal land as still exists occurs only as isolated pockets. A whole host of insects which live on this habitat are now under threat of extinction through isolation. Examples of these include various bees, wasps, ants, bugs and beetles, but the most obvious losses have occurred among butterflies. A series of bad summers can seriously deplete populations of the chalk grassland species such as the adonis blue, chalkhill blue and silver-spotted skipper. Once a colony of such species becomes extinct the isolation of the habitat usually prevents natural recolonization.

Land and sea All the features of real islands can also be applied to land-locked islands. The number of different plants and animals on a true island has been shown to increase with its surface area. A similar effect is found if other islands are near by to serve as reservoirs of potential colonists. Studies of communities on real islands may lead to better guidelines for the creation of good nature reserves.

Above: Few insects are able to reach land-locked pools such as the Lough in the city of Cork, Ireland. An exception is the southern aeshna dragonfly (above left), which has always been quick to colonize new stretches of water and so is well able to adapt to biological islands.

Below: Roads, and especially motorways, present a particular hazard for animals that undergo regular overland migrations, such as toads (below left).

TELLING DICOTS FROM MONOCOTS

The flowering plants are divided into two main groups–monocots and dicots. Here we explain their basic differences, in flower, leaf, stem and root system, so that when you are next in the field you will be able to distinguish one from another.

Almost all botanists agree that the flowering plants (angiosperms) may be divided into two major groups. On the one hand we have the monocotyledonous species, known for short as monocots, which include grasses, lilies, bamboo and palm trees, while on the other hand there are the dicotyledonous species (dicots), an extremely varied group encompassing such plants as daisies and oak trees. The division of flowering plants into these two groups has long been recognised and is generally accepted as reflecting a natural, rather than an artificial, partition.

Above: Woodiness is found among dicots but not monocots–not even bamboo is strictly woody. Thus all flowering trees, including this elm, are dicots.

Right: A beech seedling with its two cotyledons.

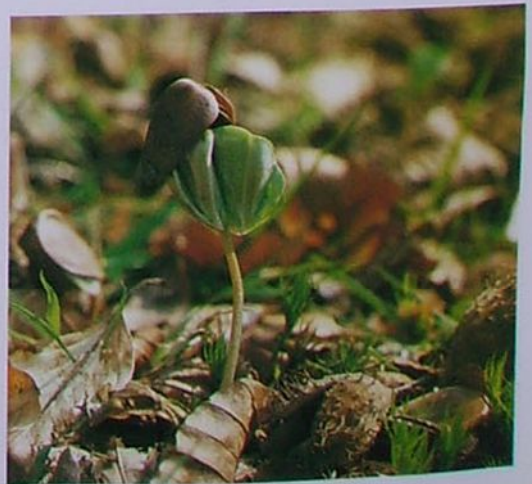
Herbaceous monocots The monocots represent only about one quarter of all flowering plant families. All of them are herbaceous, never truly woody (though some, such as palm trees and bamboo, give the impression of woodiness). Some members of the group, for example the grasses, are very advanced in an evolutionary sense, and also provide most of the world's staple foods, such as wheat and rice.

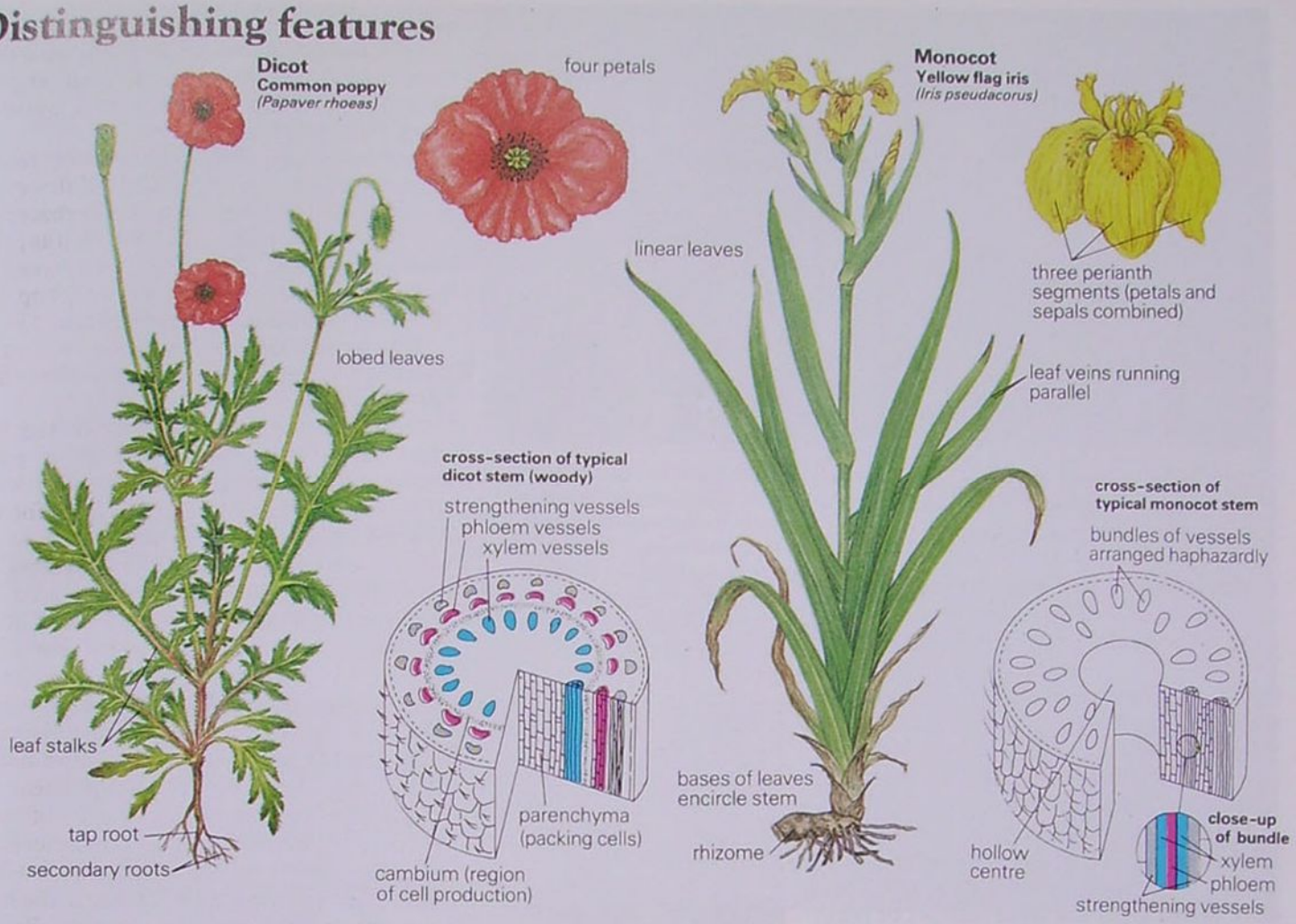
The term monocot derives from the fact that, typically, the seed of such a plant contains only a single cotyledon (seed leaf). The cotyledon serves to supply food for the young developing plant. It may remain in the seed husk, in which case it actively absorbs nutrients from other parts of the seed or, alternatively, it emerges from the seed husk, turns green, and manufactures food by photosynthesis. In most monocots the cotyledon remains inside the seed husk.

Perhaps the most obvious characteristics of the monocots lie not in the cotyledon but in the leaves. These are normally linear or oblong in shape, and have a number of veins running parallel to the long axis of the leaf. (In many cases there is no distinct midrib.) The bases of these leaves typically encircle the stem and therefore lack a stalk or petiole. Rarely are the leaf margins toothed.

The underground parts of many monocots take the form of food storage organs such as rhizomes, corms or bulbs bearing numerous roots–a simple, long, deeply penetrating tap root is absent. Since all monocots are herbaceous, their leaves and flowers typically die back during the winter so, to ensure rapid growth the following spring, food is stored underground in these bulbs, corms and rhizomes.

Monocot flowers The floral parts of monocots are usually arranged in threes or multiples of three; that is to say three or six sepals, three or six petals (some plants have structures intermediate between petals and sepals,





known as perianth segments, instead) and a corresponding number of stigmas, styles and stamens. In some flowers, such as the iris, this organisation is easy to see, but in the more advanced and specialised flowers, orchids for instance, the pattern is obscured–some petals become fused, some enlarged and others reduced in size.

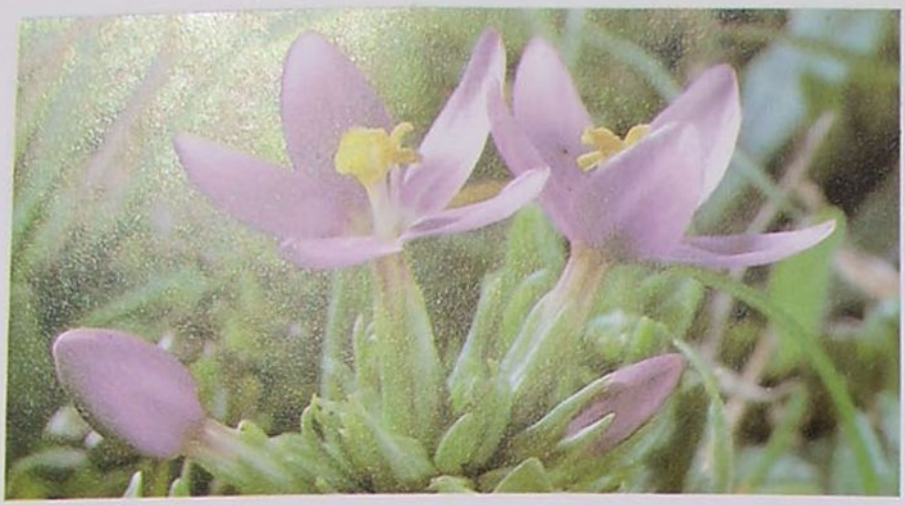
With grasses, although the male and female parts are usually in threes, their relationship to the other monocot flowers is not immediately obvious, for they lack petals; grasses are wind pollinated so they do not require petals to attract and guide insect pollinators. The pollen of most monocots is elongate in shape, and has a single longitudinal furrow.

Dicot distinctions The dicots differ from the monocots in almost every feature so far mentioned, and display considerably more variation than that seen in the monocots. Their cotyledons are usually produced in the seed and many emerge to function as if they were true leaves. These leaves are readily identified in most cases, however, because they tend to be fleshy, rounded structures, quite unlike normal leaves.

The leaves of dicots typically have a net-like vein pattern. There is usually a central midvein, but the laterals or secondary veins can radiate from approximately one point (when they are termed palmate), or depart at intervals from the midvein (when they are termed pinnate). Compound leaves, such as those seen in the horse chestnut or ash, are common in the dicots. Normally dicot leaves are borne on stalks or petioles, and small leaf-like structures (stipules) may also be present near the junction between the leaf and the stem. The leaf margins may be toothed, as in the stinging nettle, lobed, as in the oak, or may bear spines, like holly leaves.

Above: A typical dicot and a typical monocot, showing their differences.

Below: The daffodil is a good example of a monocot with its linear leaves exhibiting veins running parallel to the midrib.



In contrast to the monocots, the underground organs of dicots often take the form of a single, strong tap root, with small secondary side roots.

Dicot flowers The floral parts of dicots tend to be arranged in fours or fives and not in the monocot multiples of three. Nevertheless, like monocots, dicot flowers can be highly modified to enhance pollination by a particular method. The petals may be entirely absent in wind pollinated species such as willow, or the petals may be fused, and the flowers massed into compound heads as in the daisy family.

The simple oval-shaped pollen with a single furrow, so typical of the monocots, is only seen in the primitive dicots. The more usual dicot pollen grain has three furrows or pores and tends to be roughly spherical.

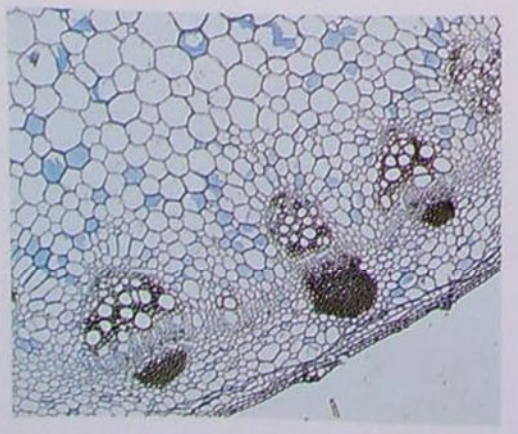
Where confusion arises In spite of all these differences it would be a mistake to assume that the division between monocots and dicots is always distinct. If you take the feature that gives the groups their respective names–the number of cotyledons–you may find that many monocots, in fact, have two cotyledons, while some dicots can have only one, or sometimes three or more.

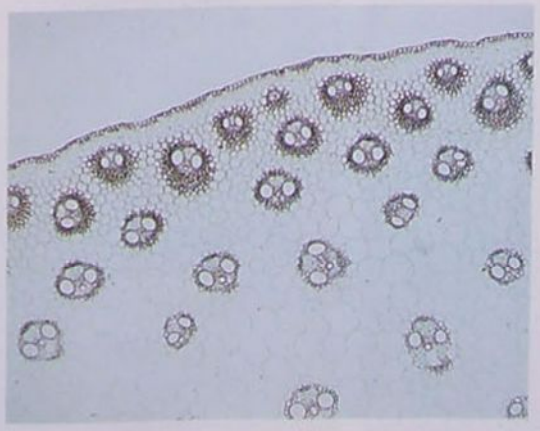
As far as the root systems are concerned, the absence of a main tap root in monocots represents only a modification in the way that the root develops, and as such it is not surprising that many dicots also lack a primary root system. Examples of this are seen in the water-lily and umbellifer families.

Evolutionary history The similarities between the monocots and dicots suggest that they evolved from the same non-flowering plant ancestors. However, obvious differences between the two groups indicate that they diverged relatively early on in the evolutionary history of flowering plants: this interpretation is supported by the fact that fossilised pollen and leaves of both the monocot and dicot types have been found in rocks that are 120 million years old.

Which group is the oldest, then? Unfortunately this question is not an easy one to answer. To date, the fossil record has been of little help, for among the earliest flowering plant remains we find evidence of plants attributable to both groups. Botanists are therefore forced to try and answer the question by examining living plants to see which have the most primitive features. Here again the evidence is not that clear, but the dicots are usually regarded as being more primitive, and therefore older than the monocots.

Above and below: With a little practice you can soon learn to distinguish dicots and monocots at a glance. Centaury (above) with its five-petal flowers is a dicot, whereas snowdrop (below) with three petals and three sepals is a monocot.





Stem differences
If you compare part of a dicot stem (far left) and part of a monocot stem (near left) under a microscope you see that the bundles of xylem and phloem cells (the dark patches) are arranged differently. In dicots they are organised in a ring near the outside of the stem, but in monocots there is no regular pattern, though they are less dense in the centre.

CODFISHES AND THE HAKE

Cod, haddock, saithe and whiting are of immense importance to man as prime food fishes, but they are just four representatives of the large codfish family, with some 25 British species. A similar but distinct family is represented by the hake.

There are about 100 species of codfishes, with 30 living in European waters, and about 25 in British or Irish seas. The family is at its most abundant and widely distributed in the North Atlantic, and in the North Pacific. Codfishes are found in Arctic seas, some species even living at the edge of the polar ice, while others live in southern oceans off South Africa and New Zealand, as well as off remote islands, like Tristan da Cunha.

A typical member of the cod family has three dorsal fins and two anal fins, none of which has spines, and the base of each is in close contact with its neighbour so that often the fins are almost continuous. The pelvic fins are placed in front of the level of the pectorals, and the tail fin is very distinctive, for the body seems to run into the fin, with the fin rays emerging above and below the tail to form the upper and lower sides of the fin.

There are, of course, exceptions to this general plan, but all codfishes have the characteristic tail fin. One of the exceptions is the group of long-bodied codfishes that have only two dorsal fins (the first being short and rounded) and a single anal fin. This group includes the ling, the burbot and the fork-beard. Related to these are the rocklings, with a reduced first dorsal fin, and the torsk which has only a single dorsal fin.

Hake family The hakes, a separate family, are similar to the cods but lack a chin barbel

Above: A shoal of young cod swims past. The three dorsal fins, the two anal fins, the position of the pectorals and the shape of the tail fin are typical of the greater part of the codfish family. Characteristics of the cod itself are the long chin barbel, the blotched, sandy green body colour and the rounded first dorsal fin.

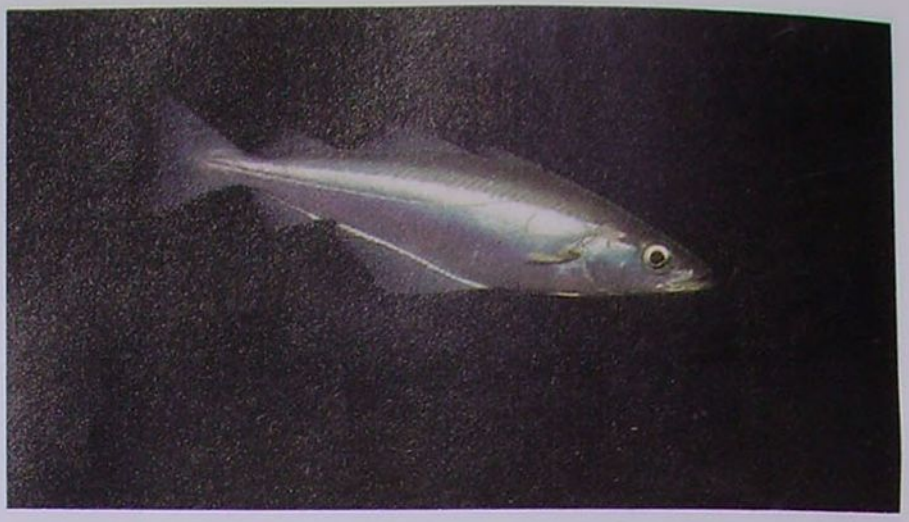
Right: The poor cod has similar fins to those of the cod, but is only about a sixth of the size.

and have only two dorsal fins and one anal fin; the mouth and teeth are large. Generally, hakes live in moderately deep water. There are seven or eight species worldwide but only one (*Merluccius merluccius*) is found in British seas. Hakes are more widely distributed than the cods, and occur on both sides of the North Atlantic, the South Atlantic, along the American Pacific coast from California to Chile, and off New Zealand and southern Australia.

Over-exploitation Both the hakes and the larger members of the cod family are important fishes for food and for the fishing industry. They all have the three advantages that make them a major target for fishermen: they have well-flavoured white flesh, they grow to a large size, and they form schools, which make them vulnerable to capture *en masse*. Unfortunately, these very qualities make them so desirable that over the years they have been seriously over-fished, and today there are far fewer large cod and haddock than there once were, and the fishery for hake that thrived off south-western Ireland is almost extinct.

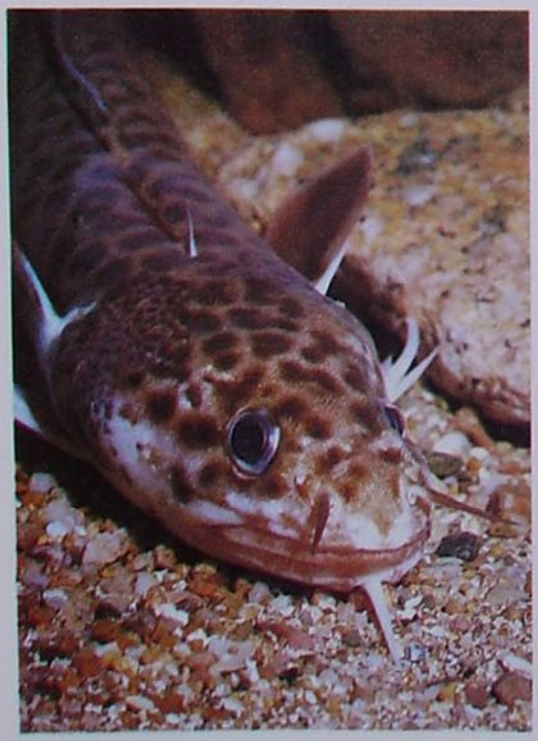
Range of habitats All the hakes and the codfishes are marine fishes except for one species, the burbot (*Lota lota*). This lives in fresh water in the cooler parts of the Northern Hemisphere, extending right up to the Arctic Circle in the Soviet Union and Canada. Its range is literally circumpolar and only in Britain, where it lived in eastern English rivers, has it become extinct.

Shoreline fishes Possibly the most accessible members of the family for the naturalist to see and catch are the rocklings. They live among algae, under stones, and in rock pools between tidemarks and below low tide level around practically the whole British coast. The most widely distributed is the five-bearded rockling (*Ciliata mustela*) which has long whisker-like barbels on the chin, two on the upper lip, and another two in front of the eyes. A closely related species, the northern rockling (*Ciliata septentrionalis*), is found in tide pools on the north-eastern coast from Yorkshire to the Scottish border, and probably beyond. The west coast of Britain has an additional rockling, the shore rockling (*Gaidropsarus mediterraneus*).



Above: The pollack, a typical inhabitant of wrecks and reefs, is a brownish green codfish with a conspicuous green lateral line that takes a downward curve at a point behind the pectoral fin. It lacks a chin barbel and does not hunt on the sea-bed, but catches small fishes, mainly sandeels.

Below left: The common or three-bearded rockling (*Gaidropsarus vulgaris*) is a different species from the shore rockling (*G. mediterraneus*), though both have three barbels. Rocklings are codfishes with two dorsal fins, the first of which is reduced. They live on the sea-bed, using their barbels to locate food. Not all live among rocks–some are found on mud and sand, and their habitats range from the shore to a depth of several hundred fathoms.



Off the coast Offshore, but still in shallow water, other codfishes abound. Every reef or wreck has its schools of dusky, barred golden-coloured bib or pouting (*Trisopterus luscus*). Small specimens of pollack (*Pollachius pollachius*) are found close to rocks, escpecially in the south and west, while large ones (these grow to 1m/40in) live in deeper water near reefs and around wrecks. The pollack has beautiful dark greenish brown colouring on its back, and the lateral line is dull green. This is a useful identification point, for its close relative the saithe (*Pollachius virens*) is very similar in appearance and coloration except that it has a pale lateral line.

In inshore waters over sandy bottoms in depths of 20-50m (11-27 fathoms) the whiting (*Merlangius merlangus*) is abundant all round the coast. It lives just off the sea-bed, although it does forage on the bottom, feeding on sandeels, shrimps and crustaceans. Its name stems from its basically silvery-white colour but in life its back is sandy to greeny

Below: The whiting has a slender body and a rather narrow, pointed head. The chin barbel is hidden in this picture.

brown, while the sides are white; it has a distinct black spot at the base of the pectoral fin.

Habitats of the cod Larger whiting live in deeper water down to 100m (55 fathoms) and these fish mingle with the schools of cod (*Gadus morhua*). As in most members of the family, young cod are found close inshore and larger ones prefer deeper water. Cod forage both on the sea-bed and in mid-water, taking crustaceans, worms, brittlestars and many fishes including herring, sandeels, capelin and smaller members of the cod family. The cod is a great migrator, and in winter the schools of cod move southwards. When migrating they follow the coastline, so that in December, January and February anglers catch large cod within a hundred yards of the beach at places like Dungeness and the Sussex coast.

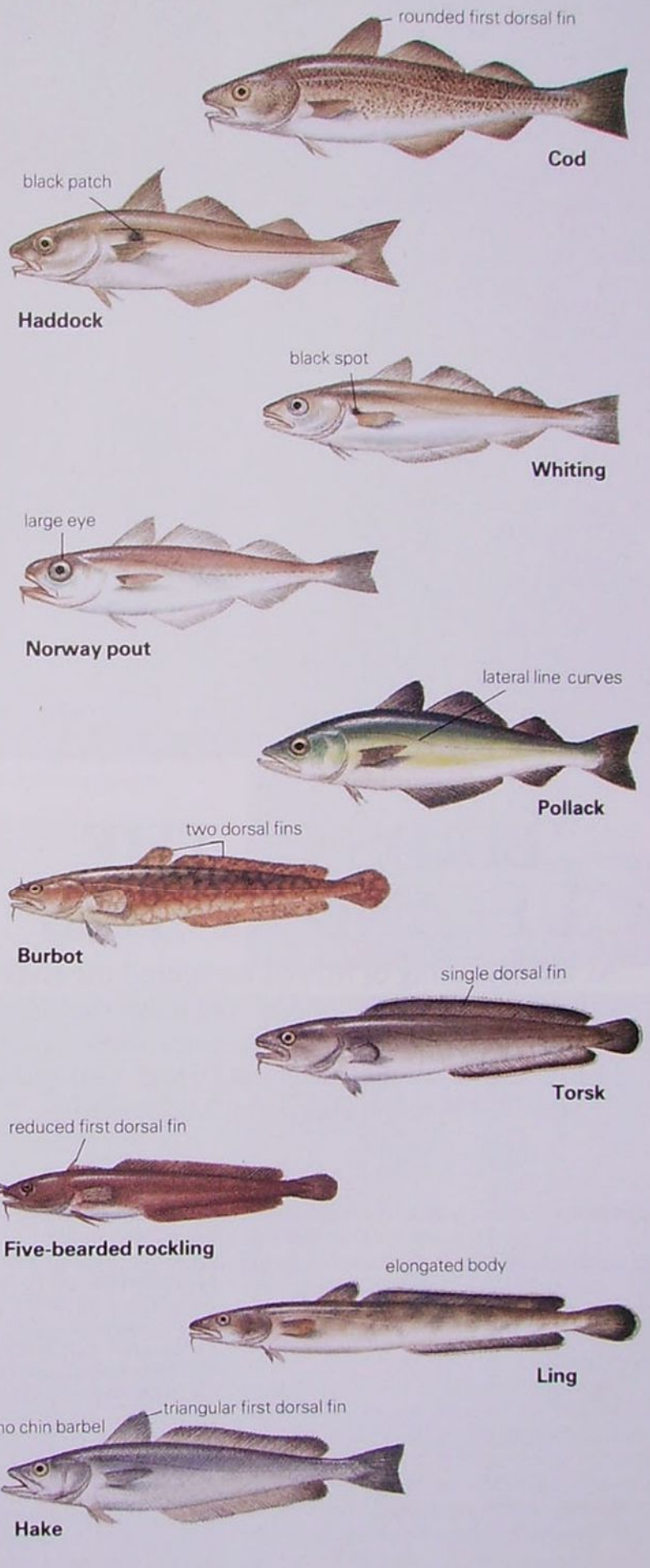
Haddock on the sea-bed No other codfish is so distinctly marked as the haddock (*Melanogrammus aeglefinus*). Its lateral line is black and it has a dusky thumb print on each side just behind the head. Its first dorsal fin is high and pointed, but its mouth is small and placed underneath the rather prominent snout. This suggests, correctly, that the haddock is a bottom feeder and its food is composed mostly of worms, brittlestars and molluscs. Occasionally in Arctic waters the haddock feeds on a strong-smelling sponge on the sea-bed, and this causes the flesh to become tainted, so that if the fish is not gutted immediately it is spoilt for consumption.

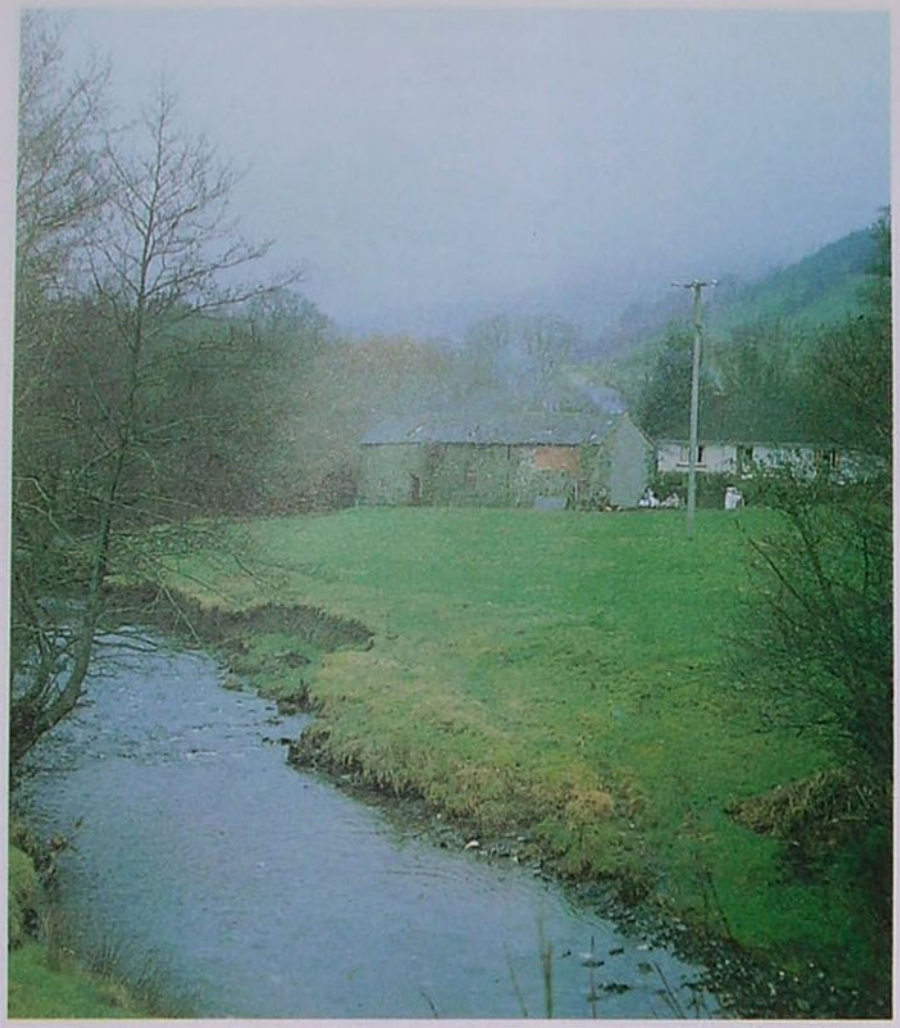
Mid-water fishes Not all codfishes feed near the sea-bed. The blue whiting (*Micromesistius poutassou*) is a mid-water oceanic fish that lives far out along the continental shelf. It teems in so many millions that attempts have been made to catch it commercially. It is easy to catch but its flesh is rather soft and insipid so it is not popular for food but, like the Norway pout (*Trisopterus esmarkii*), it could be used to make animal feed. The hake also lives in deep water near the sea-bed but not on it; its food consists mainly of fishes and squid.

Singing ability Many members of the cod family are sound producers, making quite loud noises by means of the muscles attached to the swim-bladder. Clearly they must also be able to hear the noises produced by their own relatives, as well as other species. Studies of two of the best-known sound producers, the cod and the haddock, have shown that they possess an extensive language, with different noises to indicate their presence, aggression, fear and even amorous intent.

Sensory systems All codfishes have elaborate systems around the head and on the lower jaw, while the chin barbel is richly supplied with nerves and plays an important role in finding food. In such fishes as the bib the long pelvic fins are also used as food seekers: the fish swims over the sea-bed with its chin barbel and pelvic fins thrust forwards, so as to scan the maximum possible area of the sea-bed.

Cod and its relatives





BIRDS OF THE UPLAND RIVERS

At the beginning of March we toured the river valleys of mid-Wales to find the birds that live there and, having survived the winter, were making the first moves in their breeding cycle. Our guide was RSPB researcher John McLoughlin.

Our first explorations were to the north of the valley of the River Dyfi, just into the foothills of Snowdonia. We spent the morning in the steep-sided valley of a small, tumbling river called the Corris, looking at the birds of the valley and its surrounding green slopes and swooping crags.

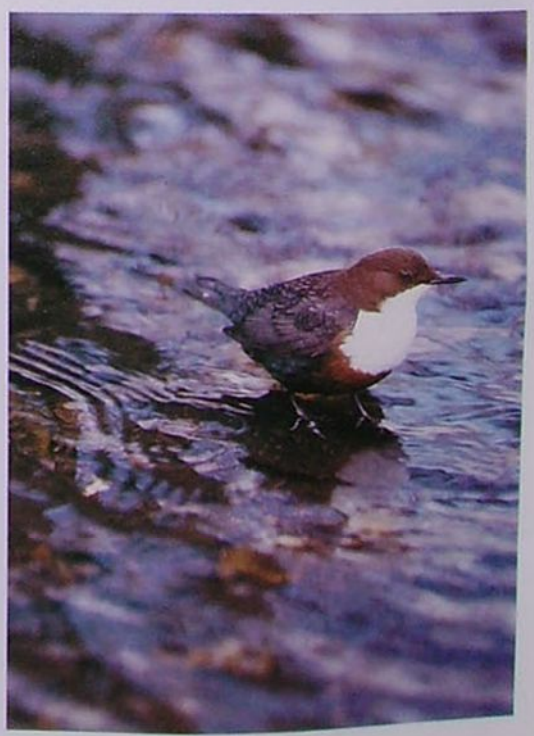
Corris valley birds The mountainsides were the home of the chough, the raven and the kestrel; down in the steep valley bottom, where tall sessile oaks rose from the stream-side, we were looking out for the grey wagtail and the dipper. Between these two habitats was another, consisting of the branches of the oaks, the hedgerows and the gardens of the small village of Corris. In this mixed habitat we saw robins, chaffinches, a siskin, blue and great tits, a coal tit and a flock of long-tailed tits; and we heard the calls of two nuthatches. From time to time a buzzard glided in among the oaks and rested on a branch.

When we descended to the bottom of the valley and spent half an hour beside the Corris, we saw neither a dipper nor a grey wagtail. The river is, however, known to have both of these birds, and is in fact one of several mid-Welsh rivers where my guide John, together with other RSPB researchers, was conducting dipper surveys.

A flock of crossbills We left this site and set off to visit a larchwood lower in the Corris valley that was known for its population of crossbills, which live on the larch seeds through the winter. As it happened, we saw the crossbills before we reached the larch-wood, for we made a stop on the way out of curiosity, and John suddenly saw them coming. They raced past overhead in a densely packed flock, uttering 'chip, chip, chip' calls. Besides the call and our initial knowledge that they frequent the nearby larchwood, John confirmed their identification by their flight formation (a dense 'squadron'), their size and shape, and the fleeting impression of colour: green in the females, and red in the males.

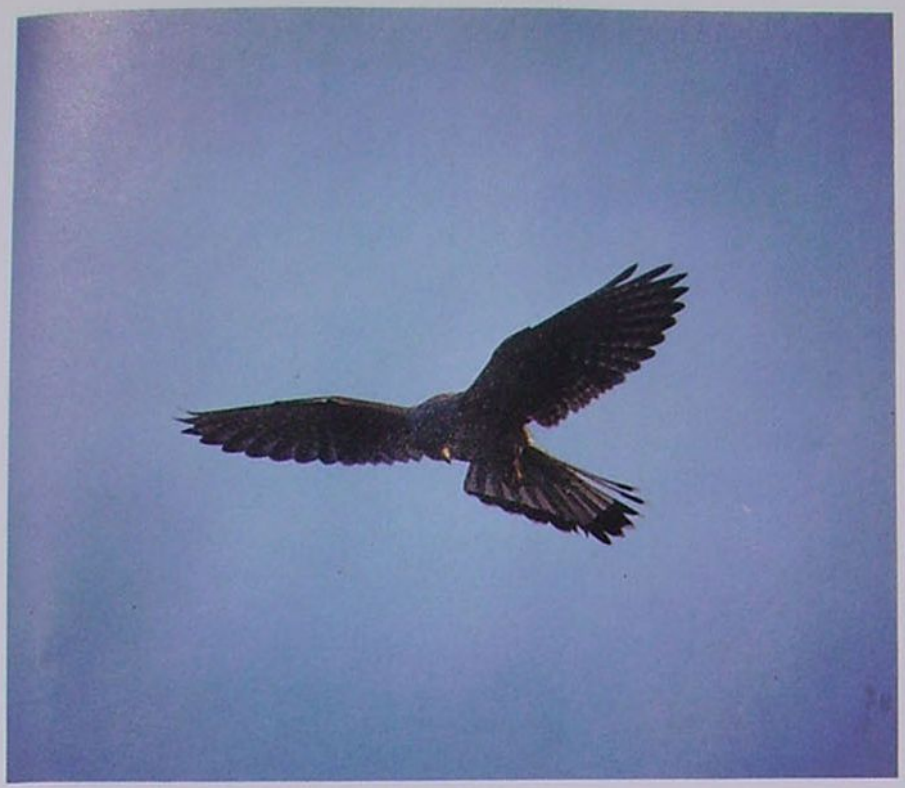
The third stop of the day was the larchwood itself, but when we arrived it was clear from the silence that the crossbills were absent.

The River Twymyn Deciding to try other waters in our search for dippers and grey wagtails, we drove down to Machynlleth on the Dyfi and crossed the river valley. We struck southwards on a winding mountain road. This crossed the moors near the summit of Plynlimon, from whose slopes the rivers Wye and Severn flow. We came down



Above: The third river we visited was the Garno. This view looks upstream from the point where we joined it. In the background is the mist-bound upper part of its valley, whence it flows on to a farmland plain devoted chiefly to cattle pasture.

Right: Characteristic of these rivers is the dipper, whose best feeding places are the fast-flowing, pebbly riffles. In among these pebbles live the aquatic animals on which it feeds.



from the moors to the village of Llan, where a stone bridge crosses the River Twymyn.

We had hardly left the car when a dipper flew out from underneath this bridge, in a single instant making good the discouragement of a whole morning's unsuccessful search. As the bird flew, we noted its whirring, pointed wings and the chocolate brown of its upperparts. It landed about 50m (160ft) away on the largest stone in a riffle, as the fast flowing stretches are called where the water splashes over an uneven, pebbly bed.

As we watched it through our binoculars, the dipper stood very still for a few minutes, seeming to gaze at the water intently: then it began to feed. It plunged its head under the surface, then righted itself and once again bobbed down. It continued bobbing actively, then jumped right off the stone and started splashing about in mid-water. After this it seemed to swim through the fast-flowing water, emerging to stand on another stone and begin casting about again.

Eventually the dipper flew upstream. At this point, the researcher taking part in a survey would probably follow it as far as the end of its territory, for the bird is strongly territorial even in winter, and when followed it is unlikely to leave its own stretch of water. It doubles back and hopes to give its pursuers the slip by suddenly flitting past–in the process enabling the birdwatcher to mark its territorial boundary on his map.

Other upland birds The stone bridge and the village mark the end of the Twymyn as a truly rushing, turbulent river. Below the stone bridge it takes a wide sweep across a flat stretch of farmland, mostly cattle pasture. We set off downstream, following the right bank; alongside this lay a somewhat marshy meadow, bordered by a line of willows some 50-100 paces to our right.

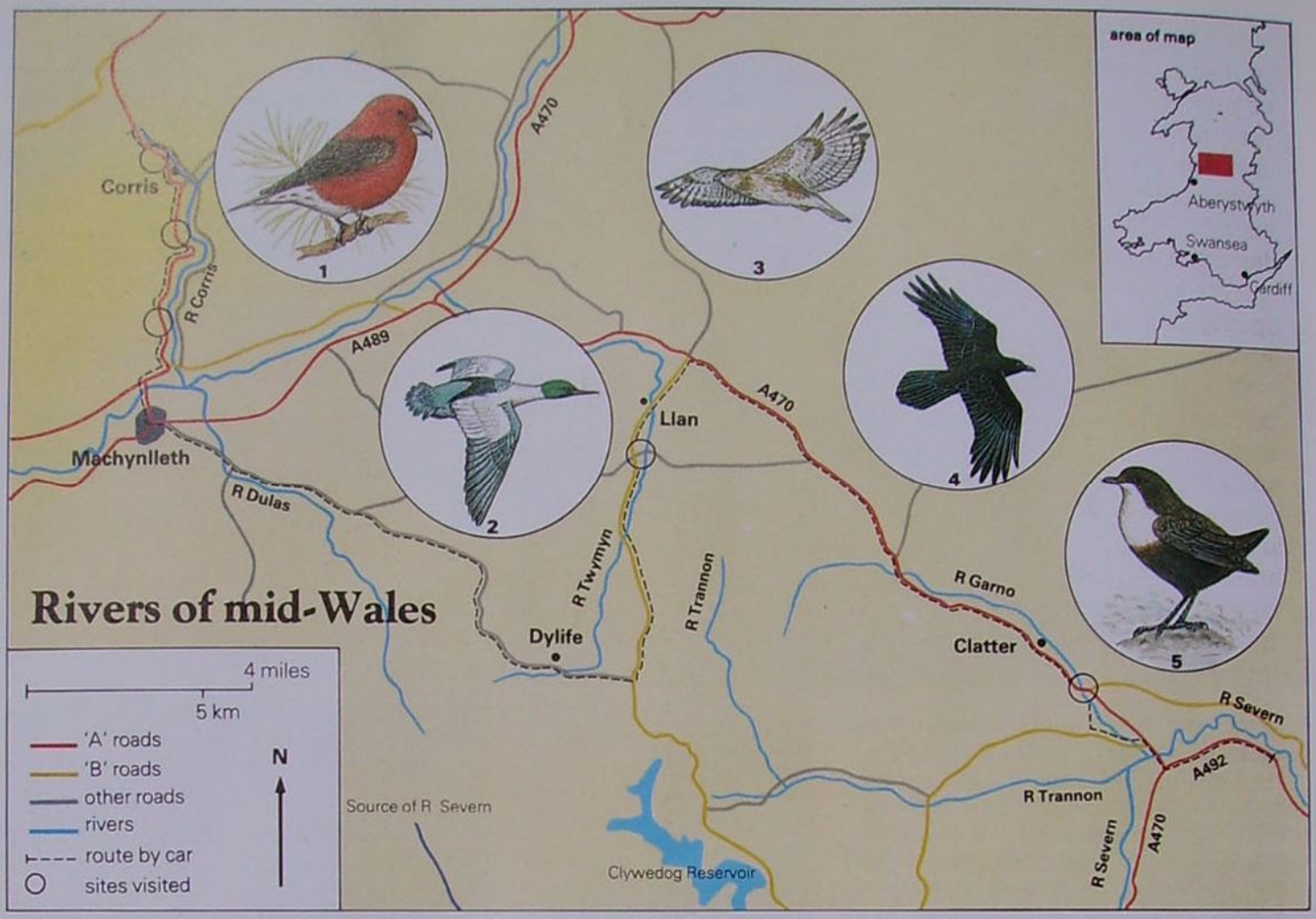
Two ravens flew over a hill some distance away (using his binoculars, John recognised their shape and flight pattern). These are quite characteristic upland birds, and are not found in the wild anywhere in, for example, southern England. Nearer by, a goosander flew past, with its neck held rigidly forward; this duck is a newcomer to Wales, having been seen breeding there only in the past 20 years or so. It was not the only duck in the valley: three mallard broke cover, ascended to just above the height of the trees and flew back and forth in a zig-zag, before going to ground further on.

The next bird we saw was a woodcock: there was an explosive flap of wings, and suddenly this unusual wader, which may well live its whole life inland and never visit the seashore, rose into view. It wheeled about and then flew straight, dodging between some trees, before returning to the ground. It is a nocturnal bird and, having been disturbed, needed nothing more than to find a new place in which to continue its daytime rest.

Above: High over the Corris stood a slate crag, brown with dead bracken from the year before; and above it a kestrel floated upwards until it was a tiny speck in the sky.

Right: The crossbill is a year-round inhabitant of the Corris valley. This is a female.

Below: Mallard nest in the meadows beside the Twymyn. The chicks hatch in April, and can walk to the river and feed themselves within a few hours of hatching.



The River Garno The Twymyn and the Corris flow into the Dyfi, but our last river was one that flows eastwards into the Severn. We stopped beside the River Garno and followed it downstream to its last, looping meander after which it joins the great river. As we walked we spotted three dippers altogether, and judged that this stretch consisted of two territories. In one we saw a lone bird, and in the other we saw the resident pair together, and heard their harsh, scratchy trill of a song.

One of these two birds gave us a particularly good chance to study it, standing quite motionless for several minutes. Very slowly we advanced towards it, and John said he could see it blinking its white, downward moving eyelid called the nictitating membrane. This protects the eye while the dipper hunts underwater for larvae, nymphs and other aquatic animals.

Northern migrants A flock of eight fieldfares took off from a large alder tree, and later several flocks of redwings came past, one with about 40 birds. The redwings called as they flew, making an easily recognizable 'dzzeee' sound. These two birds are Scandinavian thrushes that winter in Britain and Ireland. It was known that some flocks spend the winter in Wales; but it was equally likely that among those we saw were a few that had been wintering in Ireland and were here on a brief 'stopover' on their return migration.

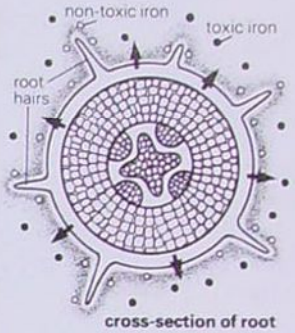
Our last sight before we left the area at dusk was a flock of 12 pied wagtails, flying to roost for the night. After the redwings and fieldfares had gone, these wagtails would be joined by their relatives the yellow wagtails. Redstarts and flycatchers would return from Africa and nest in the oakwoods of these upland river valleys of western Wales, and the new breeding season would unfold.

Above: Birds inset in the map are: **1** crossbill (male), **2** goosander, **3** kestrel, **4** raven, **5** dipper.

Below: The woodcock is a common breeding bird in mid-Wales, though it was rarely reported before 1940.

Roots for fen soils

Specialist fen plants outclass non-specialists in dealing with the toxic iron salts that occur in fen soils. Their roots release oxygen (shown as arrows in this cross-section) which converts the toxic salts to harmless ones. Being insoluble in water, these remain on the root surface in a hard, protective coating.



Left: A man-made dyke in Woodwalton Fen, East Anglia. This fen is one of the few that have been rescued from the plough and is now in the care of the Nature Conservancy Council who preserve it as a nature reserve. Being surrounded by intensively drained fields Woodwalton Fen is no longer flooded naturally, thereby maintaining the fen conditions. Instead the NCC has installed a water pumping system with which it can periodically flood the fen artificially.

FENS OF LAKE AND FLOOD PLAIN

'The land was either a gloomy waste of waters, or still more a hideous expanse of reeds.' Such was the view once held of fens. Today, with most of our fenlands gone, people are at last beginning to appreciate their wild beauty.

The dismal picture painted by the quote above concerned the Somerset Levels–an area which was once one of the finest expanses of fenland in the country. It was made by a 19th century historian and serves merely to demonstrate the complete lack of appreciation for fenlands that used to exist in the minds of most people.

Right: The fen violet was once common throughout the East Anglian fens and elsewhere. But now, as a result of drainage schemes, it is confined to just a few sites, one of which is Woodwalton Fen.

Those who lived there, however, and who depended on the fens for their livelihoods, took quite a different view. As an old fensman once said, 'Any fool can appreciate a mountain but it takes a man of real discernment to appreciate the landscape of the fens.'

Fens generally represent a transitional phase in the development of wetlands and are in a constant state of change. The evidence for their transitional nature can be seen in their failure to 'balance the books'. Consider, by contrast, tropical rain-forest. This habitat has, in terms of growth, an extremely high productivity but this entire production of organic material is balanced by the huge army of decomposers in the forest, and the system as a whole remains stable, books perfectly balanced. In a fen, however, productivity far outstrips decomposition because the most efficient decomposers cannot survive in the waterlogged conditions. Partly decomposed material slowly accumulates as fen peat, the increasing depth of which finally brings about changes in the very fen vegetation that produces the peat. Ultimately the fen, doomed by its own inability to balance the books, may be replaced by other habitats more suited to the new conditions.

Water is the life-blood of a fen because it is the high water levels at the start of the growing season–a critical and sensitive time for most plant species–that inhibit potential competitors and give the fen species a head start.

Above: Beds of common reed are a characteristic feature of any fen. In the days when fenland was harvested on a large scale reed, along with various sedges, was the main crop gathered.

Below: Parts of the Somerset Levels and the East Anglian Fens have been given over to the cultivation of osiers for the wickerwork basket industry. Osiers, which are a type of willow, are well suited to the damp fenland conditions.

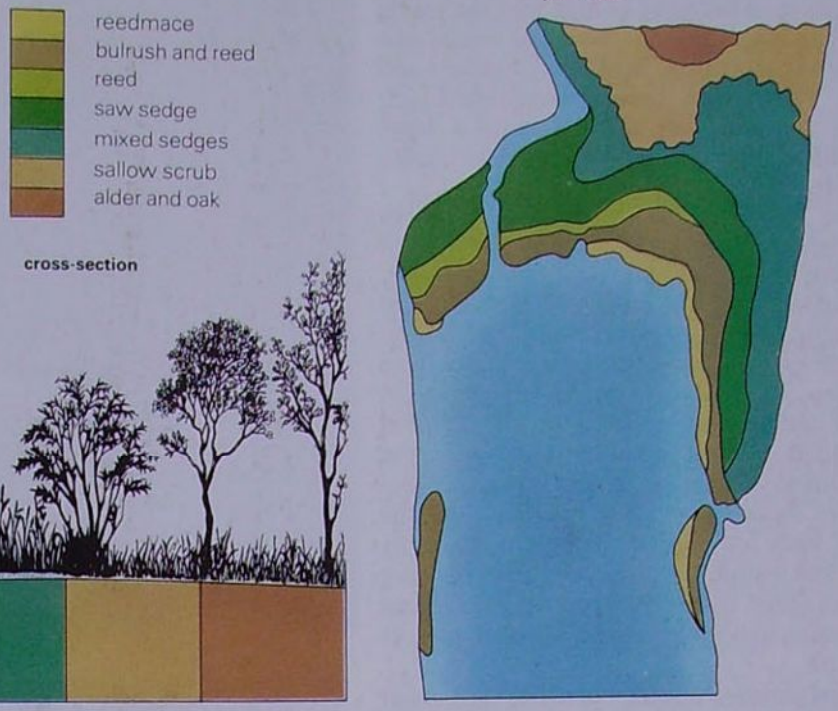
There are two ways in which high spring levels of water can arise, and each produces its own characteristic type of fen–lake fen and flood plain fen.

Lake fen No picture of a lake or pond is complete without a fringe of reeds, whether the wispy screen of common reed or the solid wall of reedmace. This is the simplest form of lake fen, also called open-water transition fen because it dominates the transition zone between open water and dry land. This type of fen is largely restricted to static water; some of the best examples are found in the Norfolk Broads.

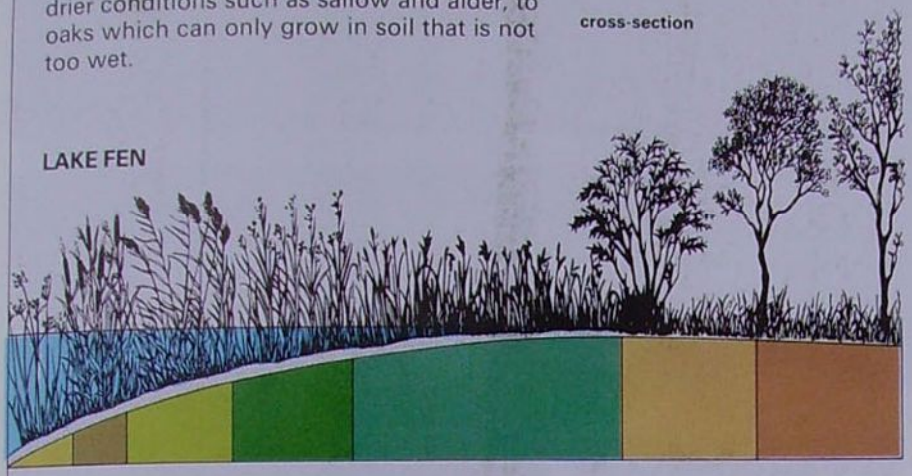
The various zones of vegetation surrounding many of the Broads reflect different stages

Two fen formations

A lake fen, also known as open-water transition fen, typically occurs on the edge of a lake, between the open water and dry land. Such a fen shows a distinct succession of different species, from the most water-tolerant ones (reedmace, bulrush, reed and sedge) actually in the water, through plants needing successively drier conditions such as sallow and alder, to oaks which can only grow in soil that is not too wet.

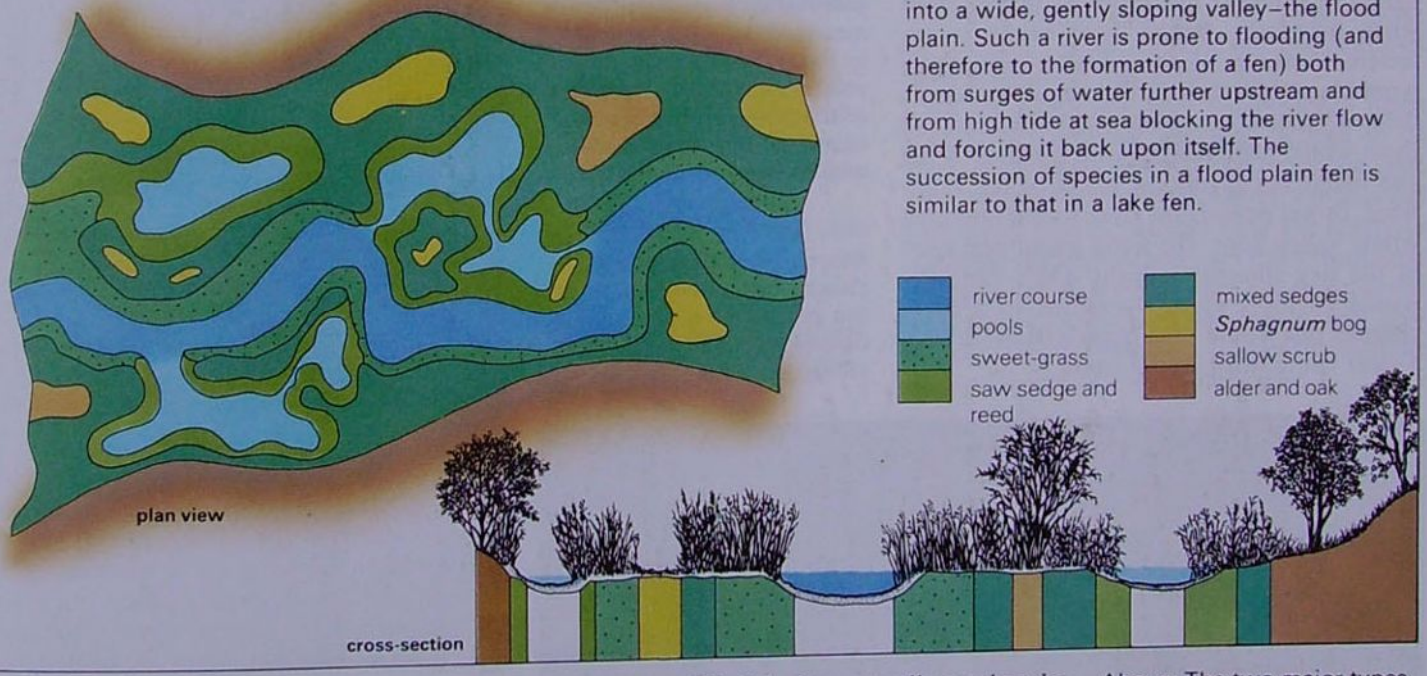


LAKE FEN



A flood plain fen, or river fen, is formed when a river in its lower reaches opens out into a wide, gently sloping valley–the flood plain. Such a river is prone to flooding (and therefore to the formation of a fen) both from surges of water further upstream and from high tide at sea blocking the river flow and forcing it back upon itself. The succession of species in a flood plain fen is similar to that in a lake fen.

FLOOD PLAIN FEN



in the accumulation of fen material, clearly demonstrating the effect of this accumulation on the species found there. The first colonizers are common reed and bulrush. In the Broads, and in southern Britain generally, these plants may be accompanied by lesser reedmace while in northern Britain water horsetail may form its own pioneer zone. The resulting mat of stems, roots and rhizomes quickly traps organic material, as well as the decaying remains of the year's growth, to form a loose, spongy reedswamp peat.

Into this rapidly stabilising mat come fen species such as hemp agrimony, water mint, greater spearwort, broad-leaved dock and great willow-herb. As the peat builds up on the bottom of the lake it eventually reaches the surface of the water, and plants that cannot tolerate extremes of flooding are then able to establish themselves. Examples include meadowsweet and yellow and purple loosestrifes. Very occasionally, rare species such as marsh pea, large wintergreen and fen sowthistle may also be found. At this point the peat surface is flooded for part of the year, but it may experience some dry periods, at least during the summer. But, where the water is still quite deep in early spring, saw sedge is likely to form dominant stands, and once saw sedge is established then another factor usually becomes important in controlling the subsequent stages, namely, man.

Above: The two major types of fen have roughly the same succession of vegetation, though it is formed in quite different circumstances. The essential difference between the two is that lake fen occurs in water that is static or moving only very slowly, whereas flood plain fen occurs around moving water.

Man steps in The natural trend after the arrival of saw sedge would be for the vegetation to continue accumulating peat until its level becomes so high that the spring flooding is no longer sufficient to inhibit saw sedge's competitors. Seedlings of sallow and alder would then become established, followed by birch, ash and oak, until a dense woodland canopy closes over a relatively dry mixed-sedge community.

The 'fen tigers', as the inhabitants of the fens were known, were far more interested in the beds of saw sedge and reeds than in woods. So, under a careful regime of flooding and harvesting they deflected the course of natural succession and prevented the woodland from shading out the economically important fen communities. An entire way of life was sustained in this manner, but sadly the reedcutters have now almost vanished, victims of recession in their industry, and the sedge beds are rapidly being colonized by alder and willow carr. After centuries of being held in check by the fens people, the natural succession to broad-leaved woodland may yet triumph.

Flood plain fen The second major type of fen is flood plain fen. As a river approaches the sea it flows out into a wide, gently sloping valley in which it has room to spread itself when necessary. Before man began to interfere, the lower reaches of most large rivers would have had little in the way of a sharply defined water-course with neat banks; instead there would have been a wide expanse of fen and marsh occupying the whole of the valley floor. In wet periods the river would flood the whole valley floor—the flood plain—and even in the dry summer months when the river would be more clearly confined to a main channel this would have been little more than a clear route through the reeds.

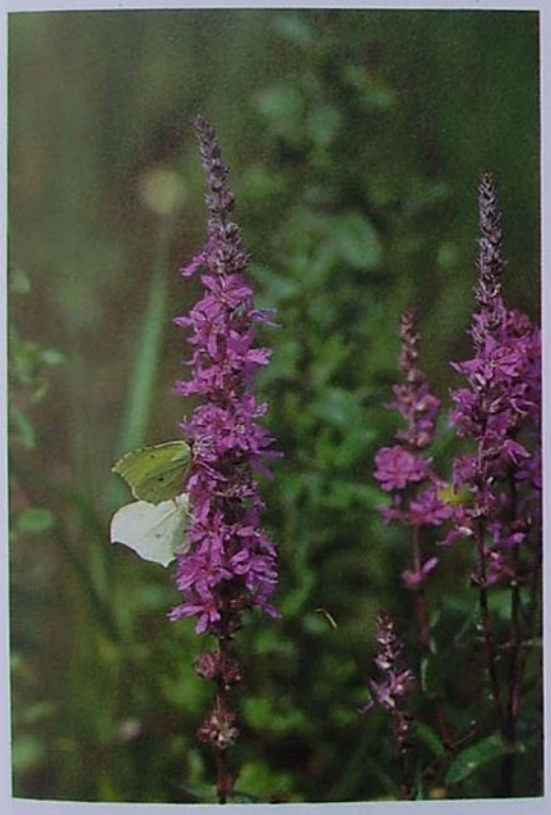
Above: The eerie booming of the bittern can still be heard in the Norfolk Broads, but it is much rarer now than it used to be. The bird itself is hardly ever seen since it is so well camouflaged against the reeds.

Right: Once the initial colonists—common reed, bulrush and reedmace—have established themselves, other more colourful plants begin to move in. One such is yellow loosestrife, a member of the primrose family also found along river banks as well as in fens.

Below: An important and characteristic component of fen vegetation is saw sedge, named after the sharp teeth along its edges.

Both the Thames and the Severn once had much wider flood plains than they do now, but the most spectacular of all, rivalling even the broad swathes of oak that covered much of Britain at the time, must have been the two areas which we now know as The Fens and the Somerset Levels. Both are immense flat plains which receive water from a considerable catchment area, yet the gradient across the plains to the sea is so shallow that at high tide the river water became ponded, flooding out across the whole area because it had nowhere else to go.

The Fens and the Somerset Levels were the places to see flood plains in their real glory: a maze of river channels spilling water through the reed-beds, eddying round areas of raised bog, and emptying into meres so large that sailors would feel sea-sick on them during storms. Sadly, today all this can be seen only in the mind's eye because The Fens and the Somerset Levels have all but gone, drained and reclaimed for agriculture, leaving four tiny pockets in Cambridgeshire and some



Above: A stand of reeds lining a water-course in Woodwalton Fen.

Left: Purple loosestrife, seen here with two brimstone butterflies feeding on its flowers. Like yellow loosestrife it is a common plant of fenland and other wet sites, such as river banks. The two species are not closely related, although they share the same common name.

Below: The otter–one of the main fenland mammals but decreasing in numbers.

slightly larger remnants in Somerset, Nevertheless, these fragments are enough to give us some indication of the vegetation that once dominated these vast areas.

Fen reserves Two of the Cambridgeshire fens that have been saved are Woodwalton Fen and Wicken Fen but, because both are now surrounded by intensively drained farmland, they no longer benefit from the regular inundation of a flood plain. However, they are supplied by artificial floods, Woodwalton Fen by virtue of a pumping system installed by the Nature Conservancy Council and Wicken Fen because the National Trust is able to flood the site from a drainage channel running through it.

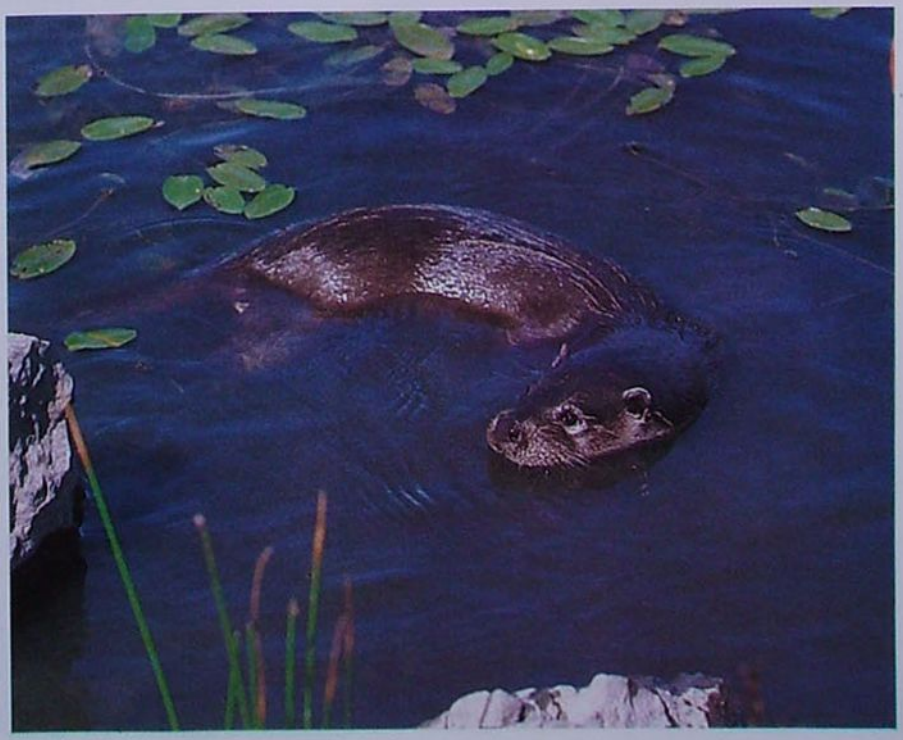
At Woodwalton Fen the combination of water flow and a somewhat acidic peat has resulted in a purple moor-grass community with saw sedge and sweet gale. There is also an extensive area of mixed fen with common reed, purple small-reed, common meadow-rue and wood small-reed. Wicken Fen has a rich sedge 'litter' with yellow and purple loosestrifes, wild angelica and marsh pea.

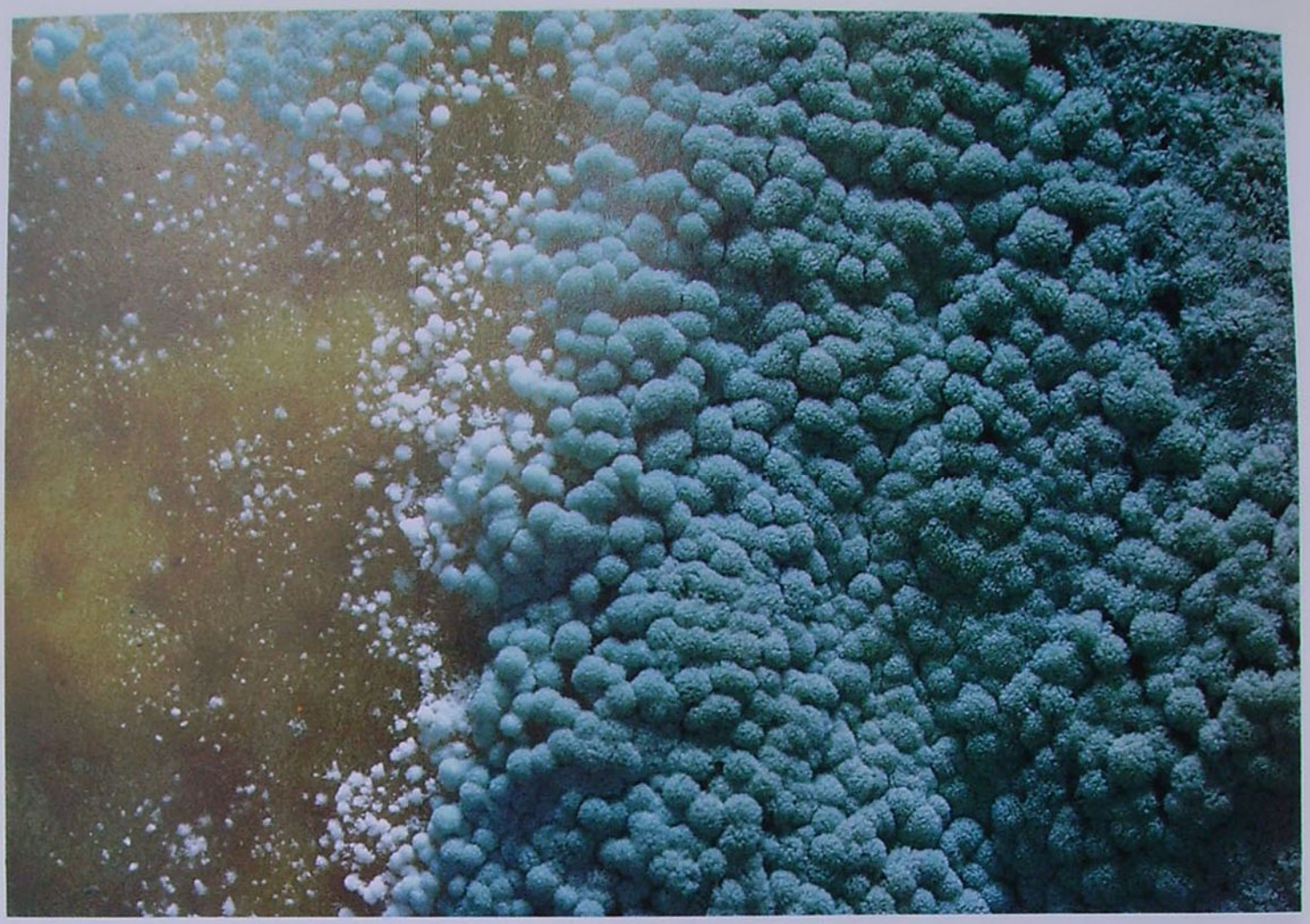
Animals of the fens Fens are particularly rich in bird life, probably because they provide so much excellent cover among the reeds and sedges and also because the dense floating vegetation limits the amount of human disturbance. Many of our rarer birds are associated with fens: the bittern, marsh and Montagu's harriers and bearded tit.

Mammal life is more restricted, the water vole and otter being the main species, though in Norfolk escaped coypu from fur farms have caused serious problems and mink, similarly escaped, is said to be even more of a pest.

The invertebrates more than make up for the lack of mammals. Deep in the peaty substrates are millions of bright red midge larvae, and water beetles, alder flies, moths, dragonflies and butterflies are all typical of these reed swamps, including such rarities as the Norfolk aeshna and scarce darter dragonflies and the swallowtail and large copper butterflies. The last of these was reintroduced at Woodwalton Fen by the NCC.

In changing the very environment upon which they depend, fens may be said to be their own worst enemy. But man, too, has played a part in their destruction, which is sad and ironic because we also have the ability to maintain these areas and save them from their natural fate. A few tiny sites are being saved but what a shame that people are only now learning to see fenland landscapes through the discerning eye of the fenland tiger.





THE IMPORTANCE OF FUNGI TO MAN

Next time you go into a larder look around at the foods made by fungi: bread, blue cheese and wine. Fungi also enter our lives in other ways, by destroying timber and food crops, and by producing antibiotics for the fight against bacterial disease.

Above: The blue fungi found on citrus fruits, such as this lemon, belong to the same genus, *Penicillium*, as those used in the production of antibiotics in medicine. One of the most cosmopolitan groups of fungi, this genus is abundant in the soil (where it helps break down plant material) as well as being common on decaying matter and in some cheeses.

Fungi are intrinsically involved, whether for good or bad, in many aspects of our lives. The most familiar of these is probably food: yeast, an essential element in baking, is a fungus. It feeds on sugars and starches (hence its scientific name of *Saccharomyces cerevisiae*), converting them into alcohol and releasing carbon dioxide as the waste product. To us, of course, the carbon dioxide is the important product since it inflates the dough. The same species of yeast is used in wine-making and brewing, where the important product is alcohol.

Fungi are also responsible for improving the flavour and texture of many foods, cheese being the most obvious example. The unique taste of blue cheeses is acquired by cultivating fungi of the genus *Penicillium* within the cheese.

Source of food Fungi also enter our diets directly, as the stalls of any greengrocer will show. One species which is extensively eaten and is commercially grown by the thousand ton is *Agaricus bisporus* with its grey-brown sporocarps, white stem and pink gills. The commonest place to find this fungus is in supermarkets and greengrocers the length and breadth of the country.

Although *Agaricus bisporus* is the major cultivated fungus in this country others, such as the oyster mushroom, are also grown. This produces a blue-grey shell-shaped fruit body which, in the wild, grows in clusters on the trunks of deciduous trees, especially beech.

In addition to cultivated mushrooms there are many edible wild fungi found in woodlands and fields. Among the most prized are ceps and chanterelles. The former has a pale brown cap with a lower surface of yellowish-white pores through which the spores are liberated; the cap is supported by a light brown central stalk. The chanterelle, on the other hand, has an egg-yellow sporocarp with an incurved irregular margin and a stout stalk the same colour as the cap.

You do have to be careful when selecting fungi in the woods, though, for there are many which are not quite such a pleasure to eat. Some are deadly poisonous, like the death cap

for which there is no antidote against the toxins it contains. Consumption of just one of these mushrooms is sufficient to cause death, so beware.

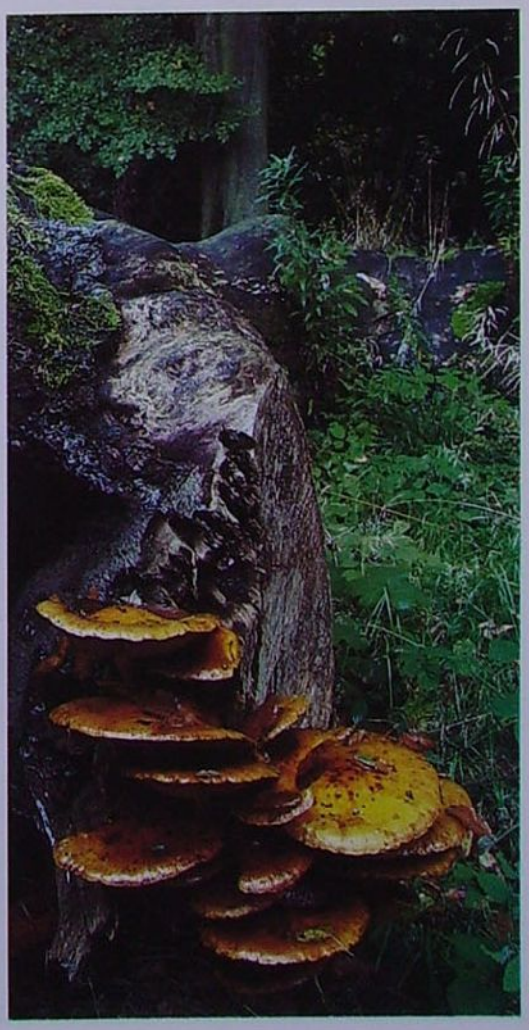
Timber parasites Other fungi often found in woodlands destroy valuable building timber. One vigorous parasite is the honey fungus, found in dense clusters on and around the trunks or stumps of deciduous and coniferous trees. Honey fungus causes a rot of trees, shrubs and even vegetables, eventually killing them. One interesting feature of this otherwise highly destructive fungus is that the hyphae glow in the dark. (Pieces of decayed wood which are permeated by this fungus will glow strongly so long as fungal growth continues.) This phenomenon has long been recognised and exploited by man–wood rotted by this fungus used to be placed at regular intervals along pathways to act as waymarkers at night.

A fungus which was used more directly for illumination was the tinderbox fungus. Its hard, fibrous, cinnamon-coloured flesh ignites readily from a spark, so that when dried it was used as a tinder in a tinderbox.

Dry rot hazard You would not think that fungi could dramatically influence the nature of the landscape, yet the recent devastation caused by *Ceratocystis ulmi* is a good case in point. This fungus causes Dutch elm disease and has greatly changed the appearance of many country areas by killing thousands of elms. It is carried from tree to tree by beetles.

Above: When mould grows on old cheeses it usually makes them unpalatable. However, in certain cheeses, like roquefort, mould is deliberately cultivated to improve the flavour. Roquefort cheese (above left) is one of the oldest French cheeses and is said to have originated when a shepherd boy left his frugal meal of bread and cheese in a cave. Unable to find where he left the cheese, he forgot about it until several months later when he found and ate it. To his surprise the mouldy cheese tasted excellent. Today roquefort is made by mixing bread crumbs infected with mould into the curd of ewe's milk.

Timber which has actually been used in housing construction is just as likely to be colonized and destroyed by fungi as that which is still growing in the wild. Most damage is done by the dry rot fungus, *Serpula lacrymans*, which infects timber when it has become sodden for some time due to leaking roofs or pipes. Infection arises from spores or by vegetative hyphae spreading through the brickwork. These penetrate the wood, producing enzymes which break it down and enable the fungus to absorb the nutrients. Since the hyphae may remain inside the timber there is often no extensive sign of their presence until severe rotting has developed. As the wood dries, it cracks into cubical



Right: Honey fungus destroys timber by causing it to rot. The fungus spreads from tree to tree by means of long black cords (below) called rhizomorphs which can be found beneath the bark of infected trees and in the surrounding soil.

blocks and eventually disintegrates into a brown powder. The fruit body of *Serpula lacrymans* can vary from 5-100cm (2-40in) in width and it spreads across a physical support such as a wall. Its margin is white and swollen, and its centre orange brown in colour.

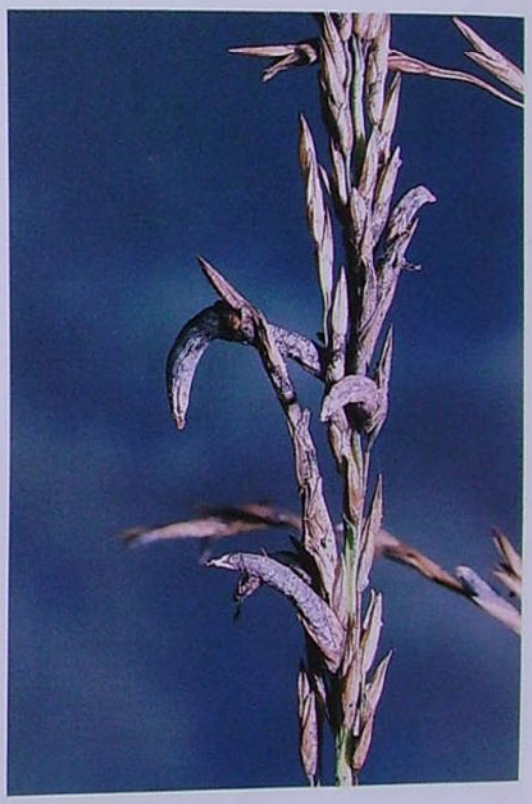
Crop failures Crop plants are other victims of disease-causing fungi, and this often results in catastrophe for the populations dependent on them for their staple food. The Irish potato famine of 1845-9, which resulted in the death of over one million people, was caused by a microscopic fungus, *Phytophthora infestans*. This destroys the foliage of the potato plant and eventually the crop itself.

In addition to wiping out food crops, fungi can make the crop poisonous to man. This applies to the fungus *Claviceps purpurea* which infects wild and cultivated grasses, covering the flower heads with purplish-black protrusions (called ergots), that prevent them from setting seed. If a crop infected by ergot is consumed it can produce the disease called ergotism, or St Anthony's fire, as it was known in medieval times. Substances derived from ergot can be beneficial, though. As early as the 16th century it was known that ergots could induce uterine contractions during childbirth, and so accelerate it.

In the human body Many fungi can actually infect man himself. One of the most familiar is athlete's foot, caused by the fungus *Trichophyton mentagrophytes* which inhabits the skin of feet. Athlete's foot is rapidly transmitted where large numbers of people are regularly exposed to skin fragments that have been shed from infected feet, in public swimming baths, for instance.

Above: Dry rot fungus is one of the major destroyers of household timbers.

Right: Cereals may become infected by a fungus known as ergot. If the crop is subsequently eaten it can cause a disease called ergotism, the symptoms of which are hallucinations and inflammation of the limbs.

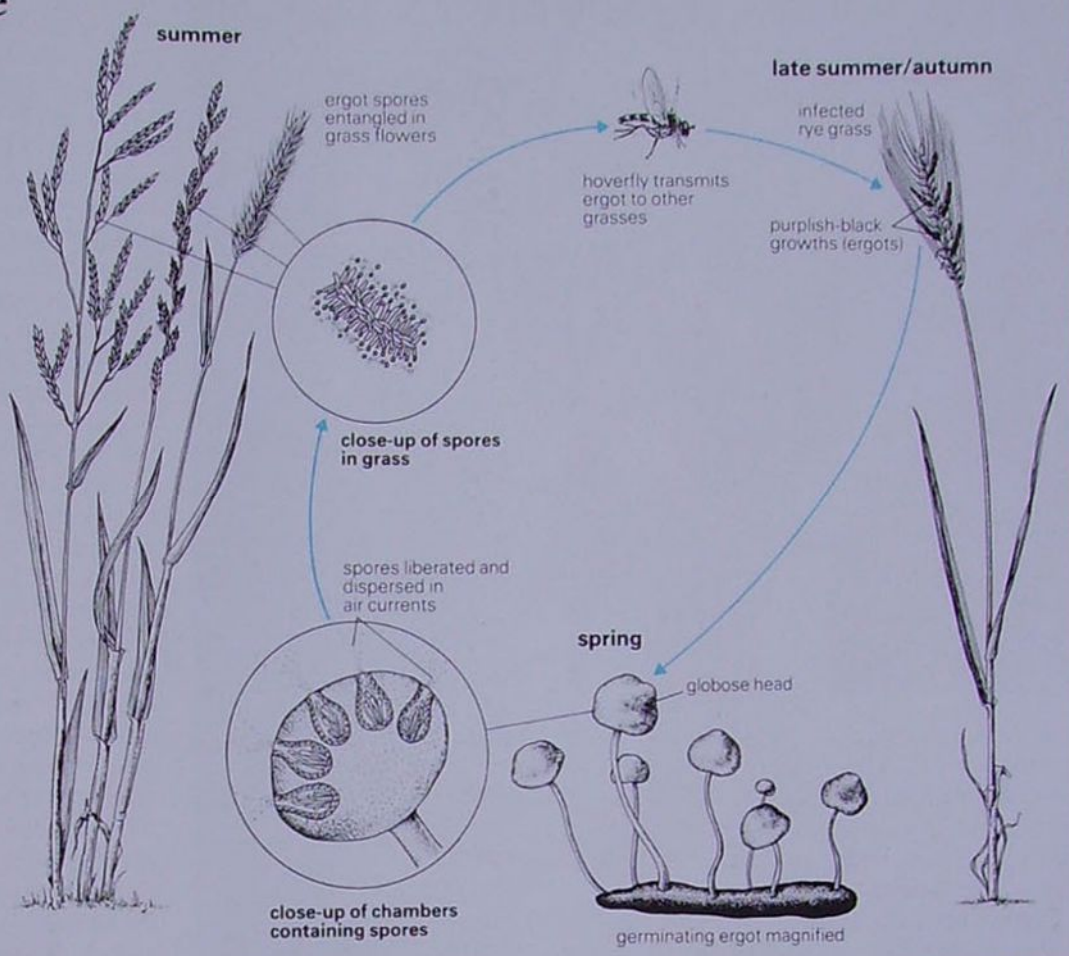


Below: The consumption of just one of these fungi is sufficient to cause death, hence its alarming name, death cap.

Fungi do, of course, play a vital part in the fight against disease. *Penicillium* has been used in the production of antibiotics ever since Sir Alexander Fleming discovered in 1928 that it could destroy or inhibit bacteria. The drug was first purified by Howard Fleury after World War II. Now it is commercially produced in enormous, specially constructed tanks, but the need to supply sufficient quantities has always been a problem and researchers are continuing to look for new sources. Antibiotic substances have been found in some of the higher fungi–mushrooms and toadstools–but unfortunately they are unsuitable for they contain dangerous toxins. Recent research has revealed that some fungi may contain chemicals that could be used in the battle against cancer, so the medical uses of fungi are by no means

The ergot cycle

Grasses and cereals infected with ergot are most easily recognised in late summer and autumn when their flowers are covered in purplish-black growths called ergots. These ergots fall to the ground in autumn, where they remain until spring when they germinate. After germination each ergot gives rise to a number of thin stalks bearing globose heads. Within these heads are numerous flask-shaped chambers containing spores, which are eventually liberated and dispersed in air currents just as the grass flowers are opening in the summer. Some of the spores land on the flower stigmas and grow into them, preventing the stigma from fulfilling its usual function. Sometimes insects, attracted by the stickiness of the spores, spread them to further grasses. Either way the spores convert the stigmas into ergots, which then drop to the ground to recommence the cycle.



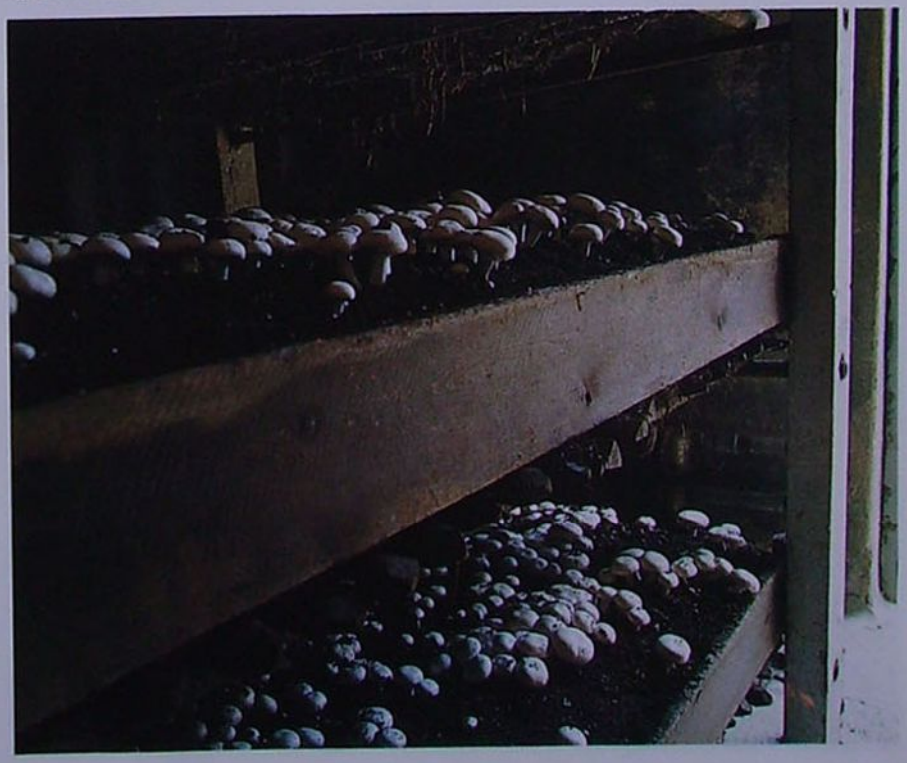
exhausted yet.

Magical fungi Long before the days when the antibiotic qualities of *Penicillium* were discovered, some of the large fungi were believed to have magical properties. The stinkhorn fungus, which erupts from eggs partially buried in leaf litter, was used as an aphrodisiac, probably because of its phallic shape.

Fairly rings, produced by the fungu *Marasmius oreades*, were originally explained as the dancing floor of fairies. The real reason for fairy ring formation is extremely simple, though–it is a fungal colony which has grown outwards through the soil from its point of origin. When small, the fungal colony is a disc, but as it increases in size the hyphae of the central region die as nutrients in the soil are used up and the colony becomes a ring. Fruit bodies, which are small and buff coloured with cream gills, are only formed at the outer rim of the colony, so marking its limit. Outward growth is maintained by the new mycelium pushing outwards, while the old mycelium behind, dies. Some fairy rings are as old as 700 years.

If you come across a fairy ring you will also notice that the centre of the ring is bare but there is profuse vegetation around the outer ring. This is because the fungus has used up all the soil nutrients in the centre leaving the area infertile so that plants cannot recolonize immediately. The lush growth around the outer ring is probably due to production by the fungus of a plant growth hormone.

That fungi were believed to have magical properties is not surprising when you consider the hallucinogenic effects of some species. One such fungi is the red-capped fly agaric which used to be eaten by Lapps at their traditional festivals.



Below: One mushroom species extensively cultivated for food in this country is *Agaricus bisporus*. The temperatures during growth must be kept constant, so they are often cultivated in disused railway tunnels.

THE RESCUE OF THE RED KITE

A large raptor with rich chestnut plumage, the red kite is an exciting bird to find on a visit to the hills of mid-Wales. The story of how it was saved from extinction during the present century is a classic in the history of British bird conservation.

Above: A red kite 'mantles' its prey–hides it from rival birds by spreading its wings. In doing so it reveals its characteristic underwing markings: black wingtips, and a white patch on the primaries. Also seen are the long, forked tail and rich chestnut plumage on forewing and body. With a total of around 100 red kites including juveniles, the Welsh population may be safe from extinction–barring a new environmental disaster like the pesticide crisis of the 1960s.

The red kite is a distinctive bird of prey, even at long distances, for it has a slender silhouette and arched, angled wings; and it flies with a lightness, buoyancy and freedom that few other birds of its large size possess. It manoeuvres dexterously in the air, sometimes with independent movements of each wing and always with precise adjustments of the long, flexuous tail. Like many large raptors it soars and glides a great deal, but unlike all others it can twist and turn at surprising speed under the canopy of woodland or among the close branches of the nesting trees.

At close quarters, or in good light, the rich chestnut of the upperparts and the tail are most striking. The underwing pattern of dark primary tips, dark 'elbow' and white patch at the base of the primaries is very distinctive. The whitish head contrasts strongly with the chestnut body colour, and the long, forked tail is always a distinguishing feature.

The red kite is a large bird, with a wingspan of over 1.5m (5ft). The only other bird that might be confused with it is the black kite, a vagrant from the Continent. This has a heavier build, uniformly dark plumage and a less forked tail.

Past persecution The history of the red kite in Britain is yet another story of annihilation of a bird of prey by man, followed by the most intense measures to protect the tiny relic population that survived. Up to the middle of the last century and the onslaught on all birds of prey that was meted out by Victorian gamekeepers, the red kite was a common bird over much of Britain.

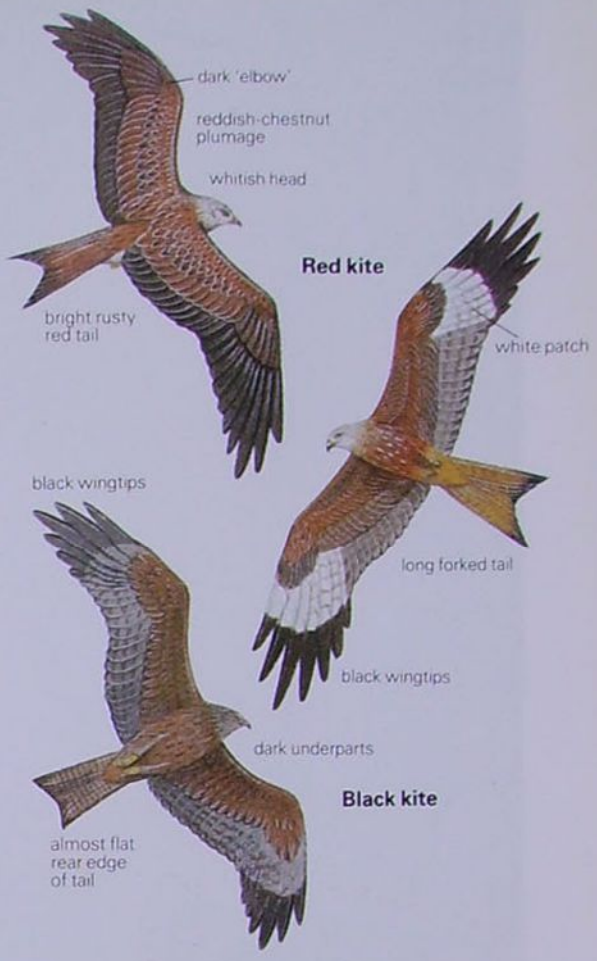
The last English kite was shot in Lincolnshire in 1847, and in Scotland the gamekeeper's trap and gun allowed the last birds only another ten years. By 1890 the only red kites left in Britain were a tiny remnant population in the fastness of remote valleys in mid-Wales, where gamekeepers were virtually unknown and no one's hand was turned against them. As the birds became rarer they also became the target for Victorian collectors of eggs and skins for mounted specimens. By the turn of the century only three or four pairs remained and the species appeared destined for extinction.

From that time onward the fate of the red kite was entirely in the hands of a few dedicated people committed to retaining the bird as a British species. The history of its protection in Britain is the classic of its type. The main ally of the bird over the decades has been the Kite Committee, an independent organisation that co-ordinates protection of nest sites and other activities in collaboration with landowners, farmers, police and local residents.

In the early years of the century the history of kite protection was filled with stories of intrigue, conspiracy and often defeat. Egg collectors were prepared to go to extreme lengths to circumvent the watchers and obtain the eggs, and the fate of the red kite hung in the balance for many years. Slowly, however, the number of birds increased, latterly under the care of the RSPB. By the 1950s it had reached a dozen pairs, but then suffered setbacks from myxomatosis and, in the 1960s, from the ecological effects of the use of organo-chlorine chemicals for sheep dips.

In 1960 the population had fallen back again to ten pairs, but by the early 1970s it had slowly climbed to 20-23 pairs. Since then a laborious increase has continued despite continuing pressures, and at present there are just over 30 pairs breeding in the valleys of central Wales.

Sightings outside Wales The red kite is most numerous in Spain, where there are possibly



Above left: The red kite as seen by most birdwatchers– an underside view, as it soars and circles over open country.

Red kite (*Milvus milvus*). Raptor resident in mid-Wales; sexes alike. Length 60cm (24in).

Black kite (*Milvus migrens*). Vagrant from Continental Europe. Length 55cm (22in).

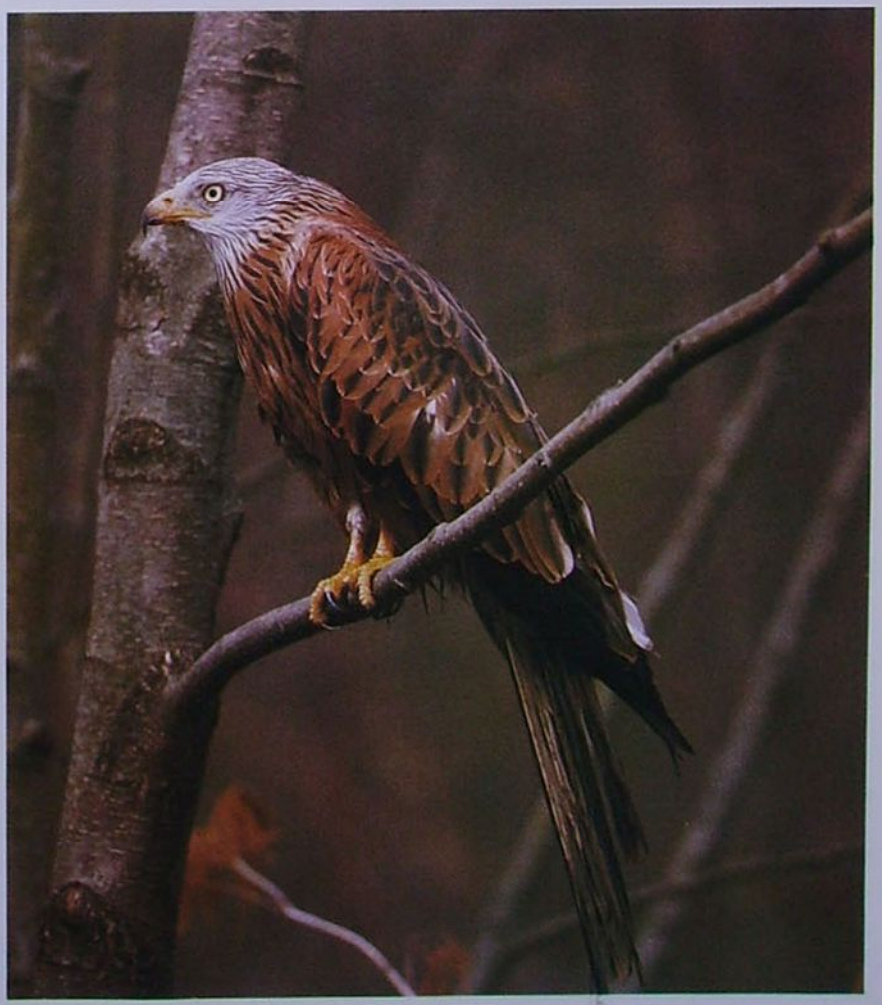
Below: A close view shows that there are black streaks in the red kite's plumage.

10,000 pairs, but individuals do occur in widely separated parts of Britain each year, normally in spring or autumn and mostly in eastern England, which suggests that these are stray birds from the Continent. Apart from these wandering individuals, the last remnants of the British population are restricted to mid-Wales.

Variety of foods Kites are scavengers by nature: in Britain, the red kits is essentially a camp follower of the sheep industry in the hills of Wales. There is always a plentiful supply of sheep carrion, and the placentae of lambs in spring are also important to the kite at a time when it has young. It hunts by soaring and circling over the open hill or valley fields, descending in lower and lower circles once it has located food. At a carcase it is usually less adept than buzzards and ravens, and certainly relies on the latter to open up the carcase with their large, strong bills.

Red kites will also take live prey if it is available, or if they have a special need, for instance when they have young to feed. In the early mornings, in the region where they live, it is not unusual to see a kite walking around on the ground picking up earthworms and beetles. When a kite has young to feed it will raid the nests of crows, black-headed gulls or other upland birds, and also opportunistically take a range of other small mammals or birds. Kites are also piratical robbers, and will pursue a large bird such as an eagle, a peregrine, a heron or a crow until it drops or disgorges its food; the kite then swoops to catch this before it reaches the ground.

Nesting in trees The red kite breeds in the hanging oakwoods of the Welsh valleys, although sometimes choosing a site in a large beech, large or isolated sycamore. It builds its nest of sticks in the fork of the tree at the end of March or in early April and lines the cup with sheep's wool. The normal clutch is two eggs, though three is not unusual. The female carries out most of the incubation, over a period of 31-32 days before hatching, and the male supplies her with food. Fledging takes seven weeks or more, but it is often nine weeks before the young birds eventually take to the wing and leave their parents.



BRITISH BUTTERFLY ROUND-UP

With just 67 species to tick off the list, butterflies are not Britain's most prolific insect group–yet they are arguably the most popular.

Above: The peacock butterfly is typical of the nymphalid family with its bold, colourful wing markings. This is one of our longest lived butterflies: it emerges in August, hibernates through winter and then emerges once more in spring.

Below: A large white butterfly on a cabbage: the popular name of 'cabbage white' applies to two British butterflies–this one and the small white. The caterpillars of both feed on cabbages.

Butterflies, together with moths, make up the insect order Lepidoptera. The butterflies form a very small part of this order–only 2 super-families out of a total of 21–yet, despite their small numbers, butterflies are by far the most familiar and popular group within the Lepidoptera.

From a world total of between 15,000 and 18,000 butterfly species, only 400 or so occur in Europe, and of these we can only expect to see something like 67 species in the British Isles. This number includes at least nine rare migrants and several that are rare or very local in their distribution. Of the more common and widespread species, the interested naturalist can expect to see 40 species without making special excursions.

The British butterfly species are unequally split between two super-families; the Hesperioidea, which contains the skipper butterflies, and the Papilionoidea, which contains all other families.

Lively skippers The skipper butterflies differ in several ways from the rest of the butterflies, both in structure and behaviour. They have a number of features which are reminiscent of moths; thick, muscular, hairy bodies, broad heads, and antennae with almost pointed, rather than rounded, clubs. Their wings are short and sharply angled; most species rest with their wings held out sideways and their forewings raised at an angle of 45 degrees to

the hindwings.

The skippers are named because of their distinctive rapid, darting flight, which makes them difficult to follow. The males often defend territories and dart out at any passing butterfly, irrespective of whether these are skippers or not. Most species use grasses as their larval foodplants, although the grizzled skipper feeds on wild strawberry and the dingy skipper on bird's-foot trefoil.

Solitary swallowtail The remaining British butterflies all come within the super-family Papilionoidea. This name is derived from the most spectacular butterfly family, the swallowtails or Papilionidae. These are a prolific tropical and sub-tropical family and represented in Europe by only ten or so species, only one of which occurs in Britain.

The British swallowtail, *Papilio machaon britannicus*, is a unique race of the paler yellow continental *Papilio machaon bigeneratus*, which occasionally crosses the Channel to breed in Kent. The British race has adapted to fenland habitats and is now restricted to one or two sites in Norfolk.

Like skippers, the swallowtail has its first pair of legs fully functional–a primitive character as far as the evolution of butterflies is concerned. The adult is typical of most swallowtails in possessing two 'tails' projecting from its rear wings and being a powerful, graceful flier.

White and yellow One of the most familiar butterfly families is the Pieridae which includes the common cabbage butterflies and several regular and rare migrants. All are distinguished by their wing colours, these being some shade of white, yellow or orange. In addition to the cosmopolitan Pierinae and Coliadinae sub-families we also have a single example from a mainly South American sub-family, the Dismorphinae. This is the wood white which differs from the others in having a weak, slow, fluttery flight as opposed to the strong purposeful flight of other pierids.

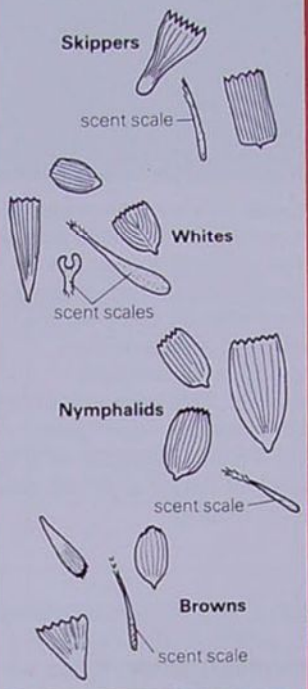
Many whites, and all of the genus *Colias*, are migrant species, adapted to a life-style of exploiting suitable habitats. One species, the black-veined white, has become extinct in the past 100 years after once being a pest of apple orchards in Kent.

Blues and coppers The huge family of small and often brightly coloured butterflies known as the Lycaenidae is represented in the British Isles by two sub-families. These are the Lycaeninae, which contain the 'blues' and 'coppers'; and the Theclinae which include all the hairstreaks. The Lycaeninae are much more conspicuous than the Theclinae because they feed on low-growing flowers.

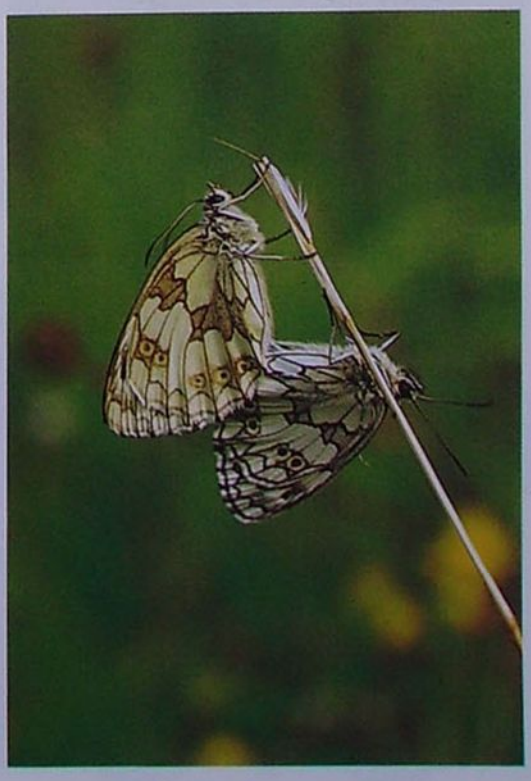
The blue butterflies are usually found on open grassy hillsides, or road verges where their foodplants grow. One species, the holly blue, frequents hedgerows or woodland edges containing holly, dogwood or ivy, all suitable as food for the caterpillars. The adult 'blues'

Butterfly scales

The 'scales' on a butterfly's wings are actually flattened hairs. They occur in two forms: clothing scales create colour and pattern, while scent scales spread scents for courtship.



Above right: A swallowtail butterfly, just emerged from its chrysalis. It has three pairs of walking legs–a characteristic of primitive butterflies.



Below right: A mating pair of marbled white butterflies. You can see that these have only two pairs of walking legs.

Below: Green hairstreak butterflies also display the primitive characteristic of having three pairs of walking legs.

are unusual in that, for many species, it is only the male which has the typical blue colour, the female often being drab brown.

Of the two species of coppers in Britain only one, the small copper, is indigenous, (the British race of the large copper became extinct almost 100 years ago). The remaining colony of the large copper butterfly is derived from Dutch stock which was introduced to this country in 1927. As in 'blues', it is the male large copper which has the more spectacular colouring of solid bronzy-copper.

The second sub-family within the Lycaenidae are the hairstreaks which, unlike their close relatives, are butterflies of the tree tops. The adults lead secretive lives on or near their larval foodplants–bushes or trees in woods and hedges.

False fritillary A family closely related to the last one is the Nemeobiidae and is another predominantly South American group. In Britain we have a single representative–the Duke of Burgundy fritillary–which is not in any way related to the true fritillaries. It is unusual among British butterflies in laying its eggs in small batches, usually between two and eight, or sometimes just a single egg, even.

Brush-foots The family Nymphalidae is one of the largest and has a worldwide distribution. Most species are colourful, often strikingly patterned and powerful fliers. Some, notably the painted lady and red admiral, are regular migrants.

Above: The metallic blue colouring of this male adonis blue butterfly makes it a conspicuous insect of open downland. In contrast, the female is a deep brown colour and much less obvious. This type of colour difference between males and females is typical of the lycaenid family to which the blues belong.

Below left: A pearl-bordered fritillary butterfly, one of the nymphalid family. These are called brush-foots because of their remarkable modified forelegs, which are very hairy and serve as organs of taste rather than legs. Indeed, they are so unlike legs that they are hard to recognise–in this picture they are partly hidden by one of the middle pair.

Below: This grizzled skipper shows three features of the skipper butterflies: a broad head and thorax; widely spaced eyes; and a pair of pointed and almost moth-like antennae.

The group name of brush-footed butterflies describes the adults' forelegs which are covered in long hairs and useless for walking. They are adapted to act as organs of taste, useful to the feeding adult and egg laying females.

The familiar groups within this family include the fritillaries, tortoiseshells, peacock, white admiral and purple emperor. Each group within the family has its own characteristics and foodplants but almost all are powerful fliers with exotic-looking spiny caterpillars.

Browns and satyrs The most familiar butterflies of farmland and rough meadows are members of the family Satyridae, which share with the Nymphalidae the feature of brush-feet. All are some shade of brown, except for the black and white marbled white: all have some form of eye spotting on their wings and characteristically swollen basal wing veins. They occur in grassy places because their larvae eat grasses. A remarkable habit of some satyrids is the behaviour of the females, who drop or squirt their eggs in the vicinity of suitable foodplants.

The flight of adult satyrids is usually slow as they move from flower to flower, often far outnumbering all other species of butterfly at bramble blossom.

Migrant monarchs By far the largest butterfly found in Britain is the monarch, or milkweed butterfly. This species is not a resident but occasionally migrates to our shores either from the Canary Isles or from as far away as North America. The monarch belongs to the family Danaidae, a group spread all over the warmer regions of the world. The monarch cannot establish itself here because its foodplant, milkweed, is not native to the British Isles.

Despite their paucity in numbers the British butterflies are no less interesting and have provided much enjoyment to many people. Their often vivid colours brighten up our gardens and they are now the subject of intensive scientific work to learn more about their ways–whether they be common insects, rarities, reintroduced populations or migrants from overseas.

Butterfly families

ORDER: LEPIDOPTERA	Super-family	Family	Sub-family	Common names	No. of species Resident	Migrant	Extinct
	Hesperioidea	Hesperiidae	Hesperiinae	Skippers	6		
			Pyrginae	Dingy and Grizzled skippers	2		
	Papilionoidea	Papilionidae	Papilioninae	Swallowtail	1		
		Pieridae	Dismorphiinae	Wood white	1		
			Coliadinae	Yellows and Brimstone	1	3	
			Pierinae	Whites	4	1	1
		Lycaenidae	Theclinae	Hairstreaks	5		
			Lycaeninae	Blues and coppers	9	2	3
		Nemeobiidae	Riodininae	Duke of Burgundy	1		
		Nymphalidae		Purple emperor, White admiral, Vanessids and Fritillaries	14	5	
		Satyridae		Browns and Marbled white	11		
		Danaidae		Monarch		1	
				Totals	**55**	**12**	**4**

Large skipper
Ochlodes venata

Wood white
Leptidea sinapsis

Purple hairstreak
Quercusia quercus

Small tortoiseshell
Aglais urticae

Dingy skipper
Erynnis tages

Clouded yellow
Colias croceus

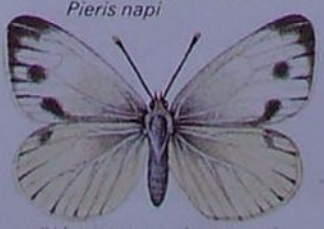
Small copper
Lycaena phlaeas

Meadow brown
Maniola jurtina

Duke of Burgundy
Hamearis lucina

Swallowtail
Papilio machaon

Green-veined white
Pieris napi



all life size except for monarch

Monarch
Danaus plexippus

slightly reduced in size

THE DARK WORLD OF CONIFER WOODS

Britain has two types of conifer wood: our native pine, juniper and yew woods, all diminishing, and the gloomy plantations of alien conifers. Though they lack the range of wildlife of broad-leaved woods, they nevertheless house several rare species.

Above: Ancient Caledonian pines in the Black Wood of Rannoch, Perthshire. Since these trees are native they support a flora and fauna far superior to that found among the dark, alien conifer plantations.

Only a very small area of native conifer woodland remains in Britain: the Caledonian Scots pine forests of northern Scotland, the juniper woods scattered thinly on limestone and the yew woods which favour steep limestone slopes. Apart from these pure stands, native conifers are a constituent of some mixed woods. Scots pine and juniper grow among birch and sessile oak in many Scottish woods, and some English oak and beech woods contain a scattering of yew.

So scarce are indigenous conifer woods that we have to look elsewhere to complete our understanding of their ecology. There are areas of coniferous woodland which, although originally planted, are similar to natural woodland in many ways. On the Surrey heaths and Brecklands in East Anglia woodlands grow which are dominated by Scots pine. These trees are of all ages, unlike those which occur in plantations, and they spread naturally. Such 'quasi-natural' conifer woods support an attractive mosaic of wildlife habitats in contrast to the depressingly uniform appearance of many plantations.

Hostile environment Two basic characteristics account for the considerable ecological differences between coniferous and broad-leaved woods. Almost all conifers retain their needles through the winter, hence casting a permanently dense shade over the ground and

Above: Sparrowhawks are common predatory birds of conifer woods, feeding on small birds which they often catch in flight. Their nest site is usually a mature conife-

Left: One-flowered wintergreen grows in some of the Caledonian pine forests in Scotland.

Below: Several species of deer inhabit conifer woods, including the red deer, although it tends to be confined to Scotland.

preventing the development of a many layered structure like that found in broad-leaved woods.

A second difference is that, unlike deciduous leaves, conifer needles are resinous and waxy so that when they fall to the ground they break down extremely slowly and give rise to an acidic litter. The presence of this resin makes the needles unpalatable to many herbivores, so it is only the specialist animals adapted to feed on them that occur in this habitat.

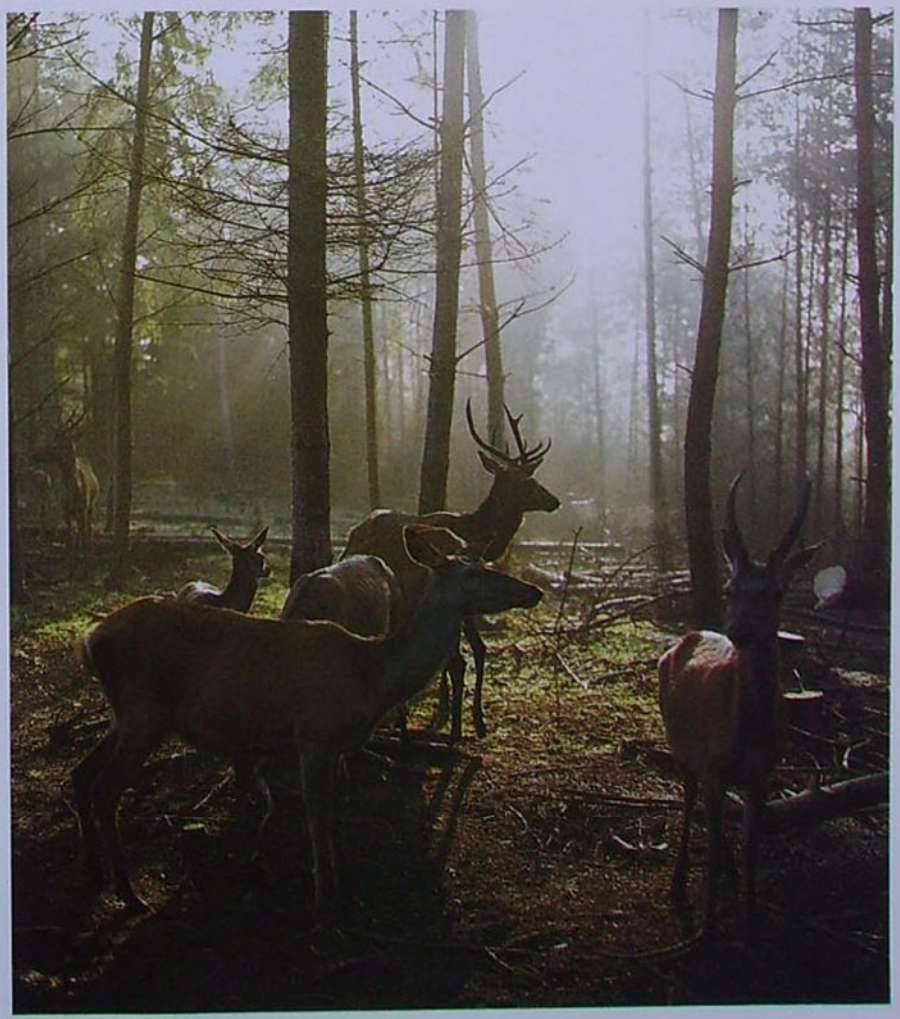
Rare flowers The combined effect of these two factors is that, for example, a typical Caledonian pine forest contains only about 20-30 different plants, dominated by heather, bilberry and cowberry, whereas ten times as many species can be found in a deciduous wood in lowland England. Yet, although sparse, the flora of Caledonian pine forests does include some national rarities. Several of the wintergreens grow in there as well as the bizarre coral-root orchid, a species more or less confined to pinewoods and having a pale yellow-green stem bearing red-flecked white flowers. Another rare species is creeping lady's-tresses, a plant with miniature, spirally arranged flowers. It was formerly confined to ancient pinewoods, but recently has been discovered in a few plantations.

Numerous fungi In contrast to the sparse number of wild flowers, an enormous range of fungi grow in conifer woods. In the absence of many invertebrates, fungi play a vital role in breaking down dead organic matter.

Species such as the rusty brown *Xeromphalina campanella* and the double-ringed *Psathyrella caputmedusae* grow in tufts on dead pine stumps. The poisonous *Stropharia hornemannii* and fascinating common bird's-nest thrive on fallen conifer branches, and tooth fungus and *Baeosphora myosura* occur on fallen cones. A whole range of fungi develop on conifer needles including the lemon-yellow elf cup, chanterelle and tawny funnel cup.

Insect life The invertebrates that occur in conifer woods can be broadly categorised into herbivores, carnivores and decomposers. Of the herbivorous species some, such as the caterpillars of the larch tortrix moth, feed on buds while others, like the pine hawk-moth and pine beauty caterpillars, feed on needles.

Among the decomposers subsisting on dead wood and fungus in rotten trees are several species of longhorn beetle and the caterpillars of the uncommon hoverfly, *Callicera rufa*.

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1 Crested tit

2 Sparrowhawk

3 Pine marten

4 Red squirrel

5 *Philodromus emarginatus*

6 Bilberry

7 One-flowered wintergreen

8 *Baeosphora myosura*

9 Tooth fungus

10 False chanterelle

Left: The permanent shade cast by conifer trees does not allow the growth of a layered structure, such as that found in deciduous woods. In conifer woods there are usually only two layers. Up in the **canopy** the beautiful, scarce, crested tit lives, excavating its nest in partially rotten branches. This bird is insectivorous, unlike the more common sparrowhawk which also nests in the canopy of conifer trees, but feeds on small birds. Two rare mammals well adapted to climbing high in the pine trees are the pine marten, now confined to the wildest parts of the British Isles, and the red squirrel which constructs its drey near the trunk of the tree. The spider *Philodromus emarginatus* also occurs high up, making its egg sac at the end of branches. **Ground cover** tends to be sparse in conifer woods, but in some places bilberry thrives. If you are in a Scottish pinewood you may also come across the rare one-flowered wintergreen. Fungi are abundant in conifer woods: *Baeosphora myosura* and tooth fungus are found on fallen pine cones and the false chanterelle grows in association with pine needles that litter the forest floor.

Below: *Baeosphora myosura*, which roots on fallen pine cones, occurs in late autumn and winter. Unlike many other fungi of conifer woods it is not edible.

Litter feeding decomposers include millipedes, springtails and earthworms.

The carnivorous species are mostly very attractive–delicate green lacewings and eyed ladybirds. In addition to these predators many parasitic species are found in conifer woods. The larvae of a species of tachinid fly feed on pine beauty moth caterpillars and a wide range of hymenopterous insects have a similar parasitic lifestyle.

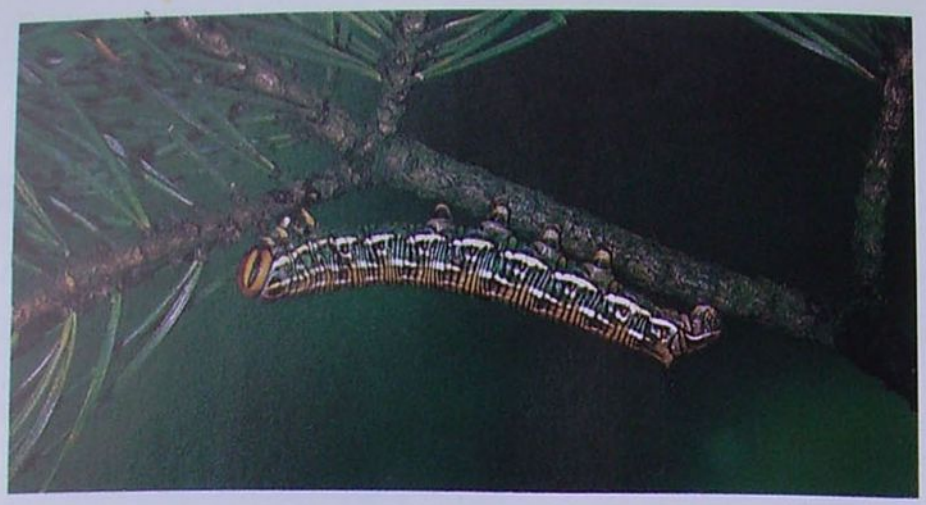
Elusive mammals Conifer woods also offer shelter to a wide range of woodland mammals. Apart from the widespread small rodents, there are a few rarer species which are restricted to conifer woods. One such mammal is the pine marten, a strikingly beautiful, graceful creature, about the size of a large cat, but distinctly weasel-like in shape. This mammal is wonderfully adapted for climbing but, because of its preference for living high up in the trees, it is not often seen.

Our native red squirrel is now an uncommon British species and only survives in extensive tracts of coniferous woodland. Smaller than the grey squirrel, it has a deep brown or chestnut coat and prominent ear tufts.

The wildcat is another native mammal which favours conifer woods. It takes mice and voles for food but can also tackle larger items of prey such as rabbits and hares. Like the red squirrel, the wildcat was formerly found throughout Britain, but now it is confined to northern Scotland.

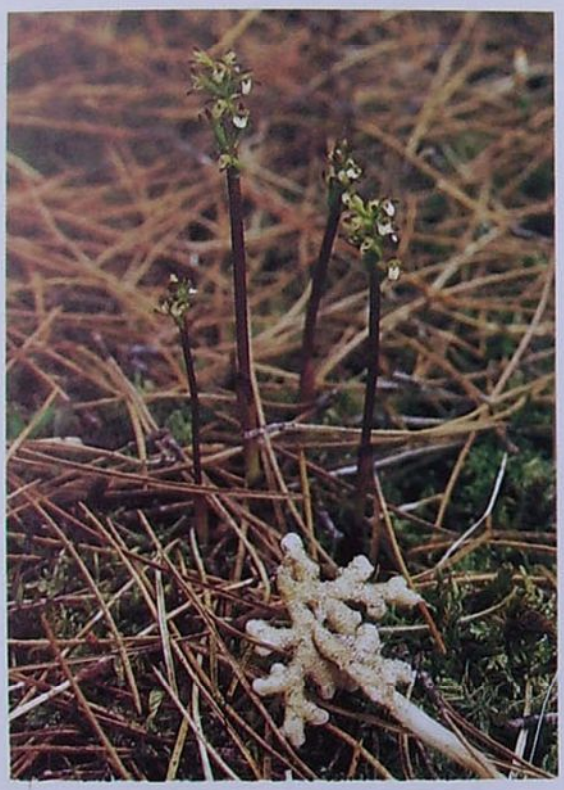
Several species of deer are regularly seen in conifer woods, though none is confined to them. Herds of the large red deer are often sighted in Caledonian pine forests where they sometimes cause damage to young trees. Two other species of deer which are numerous in conifer woods are roe and fallow deer. The former are native and prolific in northern woodlands and prefer dense cover. Fallow deer were introduced from the Middle East by the Romans and are numerous in the woodlands of southern England, causing substantial damage to young trees.

Specialised birds Conifer woods are rich in bird-life. The majority are insect-feeding but one species is specially adapted for extracting



Native juniper woods

Our native juniper woods, which grow mainly on chalk slopes, support about 35 invertebrate species unique to this habitat. Since many insects find the aromatic chemicals in juniper leaves and berries distasteful only specially adapted species can feed on them. This specialisation is dangerous, though, for the loss of juniper woods, through agricultural development on downland, has affected the insects they shelter, and many of them are now rare or facing extinction. The shield bug, *Pitedia juniperina*, and the conchylid moth, *Aethes rufulana*, are two insects to have suffered in this way.



Above: The catepillars of the pine hawk-moth, which hatch from their eggs in early August, feed on pine needles. They pass the winter as chrysalids and can be seen as adults the following year, from May to June. Like many hawk-moths the adults are large, but they are well camouflaged, and so not that easy to find. During the day they rest on pine trunks, and at night time feed on flower nectar.

Left: The coral-root orchid, showing the strange roots from which it derives its name.

Below: One of our largest ladybirds is the eyed ladybird, a species which occurs in pine forests, where it feeds on aphids.

seeds from cones. This is the crossbill, a finch with overlapping mandibles which enable it to snip the seeds from the cones of pine and spruce. (A Scottish sub-species, distinct from its European relative, is restricted to the surviving fragments of Caledonian pine forest.)

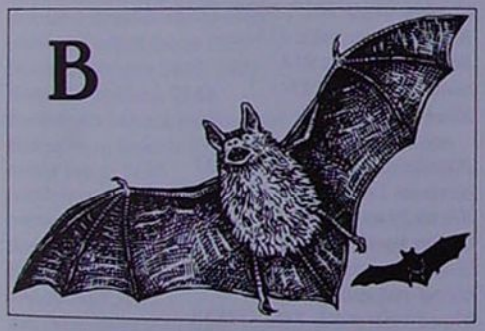
Goldcrests are widespread insectivorous birds, usually associated with conifers. They are one of the few birds to nest in dense yew woods. Closely related is the firecrest, distinguished by a pronounced white eyestripe and distinctive song. It first bred in Britain in 1962 and since 1980 has been recorded in many conifer woods in lowland England.

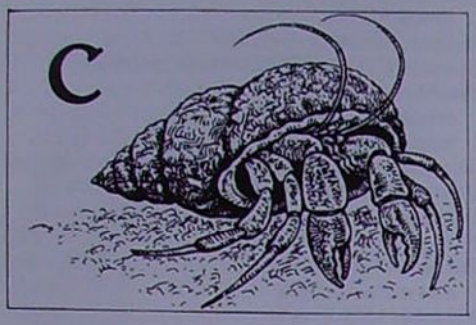
Two seed-eating finches regularly seen in conifer woods are siskins and redpolls. Redpolls are the commoner of the two, breeding throughout Britain, although they are uncommon in the south-west. Siskins breed in large numbers only in the pine forests of northern Scotland. However, outside the breeding season mixed flocks of redpolls and siskins may be sighted feeding together. Although their musical flight calls and twittering song are different, it is not always easy to tell these two species apart in a flock.

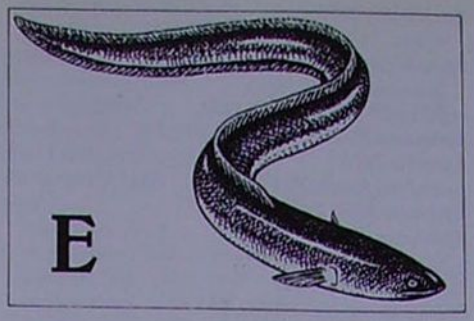
Preying on these small birds in conifer woods are the sparrowhawk and goshawk. The sparrowhawk is the commoner, and your best chance of seeing it is in early spring when the females soar high over their nesting sites in the conifer trees. The goshawk is much rarer, but it does appear to be expanding its range. As well as preying on small birds it may also take larger species such as pheasants, wood pigeons and crows; rats and hares are also an important part of its diet.

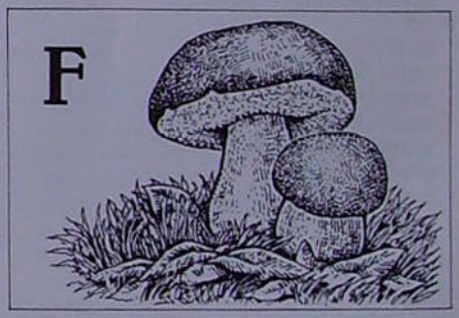
What the future holds Looking ahead, it will be interesting to see whether the extensive plantings of conifers, undertaken by the Forestry Commission over recent decades and now accounting for most of our conifer woodland, will become richer in wildlife. Possibly, as the plantations mature, the amount of light reaching the forest floor will increase and the dead wood will accumulate, so improving the range of ecological niches available, and hence allowing a greater diversity of wildlife.

The entries listed in **bold type** refer to main articles. The page numbers in *italics* indicate illustrations, and medium type entries refer to subjects in the text. Plant and animal species have been listed under both their common and their scientific names; the scientific names appear in *italics*. Where more than one species belonging to the same genus appears in the same article, then only the genus is listed. In some cases abbreviations have been used–NR, NNR and NP for Nature Reserve, National Nature Reserve and National Park.









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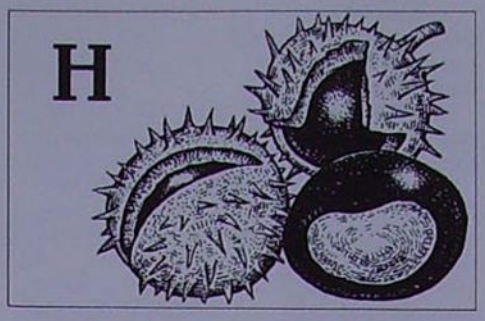

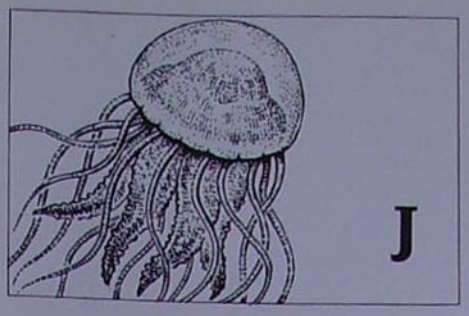

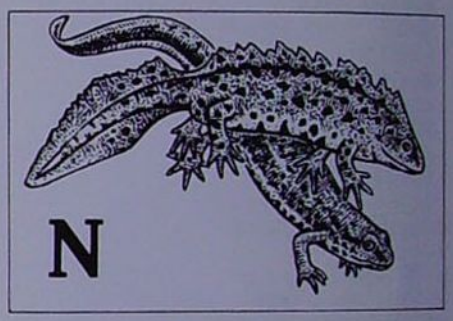

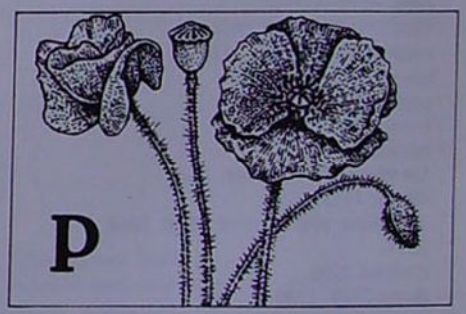

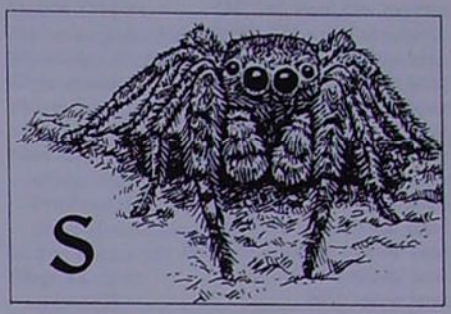

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